RT NO. DOT-TSC-NHTSA-80-6

DOT-HS-805 459

LIGHT DUTY TRUCK WEIGHT REDUCTION EVALUATION

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AUGUST 1980
FINAL REPORT

Prepared for
U.S. DEPARTMENT OF TRANSPORTATION
National Highway and Traffic Safety Administration
Office of Research and Development
Washington DC 20590

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT-HS-805 459		

4. Title and Subtitle	5. Report Date
LIGHT DUTY TRUCK WEIGHT REDUCTION EVALUATION	August 1980
	6. Performing Organization Code: DOT/TSC
7. Author(s): Norman F. Ludtke	8. Performing Organization Report No.: DOT-TSC-NHTSA-80-6
9. Performing Organization Name and Address: Pioneer Engineering and Manufacturing Company* 2500 East Nine Mile Road Warren MI 48091	10. Work Unit No. (TRAIS): HS052/R0417 11. Contract or Grant No.: DOT-TSC-1451
12. Sponsoring Agency Name and Address: U.S. Department of Transportation National Highway Traffic Safety Administration Office of Research and Development Washington DC 20590	13. Type of Report and Period Covered: FINAL REPORT October 1979 to January 1980 14. Sponsoring Agency Code: DOT/NHTSA

15. Supplementary Notes

*Under Contract to: U.S. Department of Transportation
Research and Special Programs Administration
Transportation Systems Center
Cambridge MA 02142

16. Abstract

This contract covers the identification of Types, Makes and Models which constitute the Light Truck world fleet. The attributes which describe the critical functional aspects of trucks of this size are established and specifications to define the attributes obtained. Methods of comparison of attributes are developed to provide a means of comparison leading to the selection of the most efficient design for each type vehicle. The potential for reduction of function is also evaluated.

The weight reduction potential for each selected vehicle type is determined based on size reduction, redesign and material substitution methods. Based on the preceding Product Dependent Weight reductions, related reductions in Power and Weight Dependent weights are determined to provide a total weight reduction potential. Effects of the weight reduction are provided.

17. Key Words	18. Distribution Statement
Missions, Weight Efficient Design Attributes, Product Dependent Weight Load Efficiency, Power Dependent Weight Volume Efficiency, Weight Dependent Weight Passenger Efficiency	DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	207	

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PREFACE

This study was initiated and directed by the U.S. Department of Transportation, Transportation Systems Center, for the U.S. Department of Transportation, National Highway Traffic Safety Administration, Associate Administration for Research and Development. The purpose of the study was to provide an independent assessment of the potential for weight reduction in light duty trucks. The official objective of the project states:

> "Identify the Weight Reduction Potential of Pickup Trucks, Van and Utility vehicles below 8500 lbs. GVWR by Design Modification, Redesign, and Material Substitution."

The Time Frame under consideration is 1982 - 1985.

As part of the national energy conservation effort, fuel economy regulations have been established for passenger cars through 1985. The fuel economy requirements have resulted in new passenger car designs which are smaller and significantly lighter. Similar standards (current issued through 1982) are being prepared for light duty trucks. To assist in the formulation of strict but feasible future standards, it is important to have an estimate of the potential for reducing truck weights for the period of 1982 - 1985. This study has been conducted to provide this information.

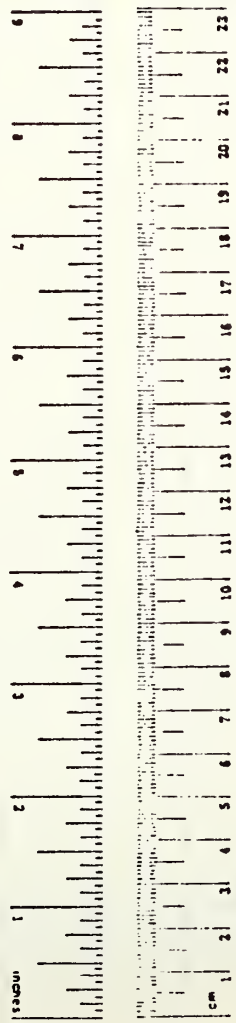
This study was conducted in 1978. Results of this study represent the best estimate at that time. Specifications and dimensions describing 1978 production vehicles were prepared by the truck manufacturers.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

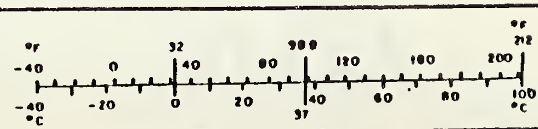
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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EXECUTIVE SUMMARY

The objective of this study is to identify the weight reduction potential of pickup trucks, vans, and utility vehicles at and below 8500 GVWR by design modification, redesign, and material substitution in the 1982 to 1985 time frame.

The missions or uses for which light duty trucks are utilized were established, and the makes and models available in this field were identified. In order to insure that the vehicle weight reduction results of this program do not impair the ability of the vehicle to perform its assigned mission, the attributes which are significant to the performance of the missions were also established. These are:

a. Load Capacity,
b. Volume Capacity,
c. Passenger Capacity, and
d. Performance.

The classifications selected for weight reduction analysis were:

a. Makes:
   - AMC (Jeep),
   - Chevrolet (GMC),
   - Dodge,
   - Ford, and
   - International.

b. Types:
   - Pickup,
   - Van,
   - Van-Wagon, and
   - Utility (4-Wheel Drive).

c. Range:
   - Up to and including 8500 pounds GVWR.

The selected classifications constitute over 90 percent of the light duty field, and the selected makes represent all U. S. manufacturers building any significant number of vehicles in this field.

Specifications to quantify the attributes were obtained from Manufacturer's Data Books. Attribute comparisons were made to compare the effectiveness of the vehicle

designs. The basis for comparison used is:

a. Load Efficiency $= \frac{\text{Load Capacity (lbs.)}}{\text{Curb Weight (lbs.)}}$

b. Volume Efficiency $= \frac{\text{Volume Capacity (cu. ft.)}}{\text{Curb Weight (lbs.)}}$

c. Passenger Efficiency $= \frac{\text{Passenger Capacity (No.)}}{\text{Curb Weight (lbs.)}}$

Graphical presentations of the results are provided to present the data more effectively and to furnish a quick means of comparing different types, makes, and models. The results (Figures 2-3 through 2-16) indicate that Dodge is the lightest and most efficient Pickup and Van. Although International is the most efficient Utility, Dodge was selected because of interchangeability with the Pickup.

Some comparisons with foreign built vehicles are included for reference. However, foreign built vehicles, generally, do not provide equivalent functions in load, volume or passenger capacity, or performance.

To improve the accuracy of the weight reduction effort, it was considered desirable to obtain actual vehicle component weights to use as a "current" base. A Dodge Pickup and Van were obtained and disassembled, and actual component weights were obtained. Visual checks were made to establish if individual components from other makes appeared lighter. Where indicated, actual minimum weights were established.

It was established that Load and Passenger Capacities, and Current Performance level would be maintained to insure that the reduced weight vehicles could still perform their assigned missions. A minor reduction of Volume Capacity was considered acceptable for the Pickup and Utility.

Design criteria were established for the components selected for specific weight reduction studies. These served as guides to insure that the "light weight" parts would still perform their required function. Components were selected on the basis of their significance to the overall weight of the vehicle, plus a technical judgment as to the potential for weight reduction. The judgmental factor utilized experience in truck engineering to assess the amount of redesign which could be used to save weight without jeopardizing function or durability. Similar judgments were made for material substitution based on current state of the art in the substitution of light weight materials for automotive applications. Criteria selected, particularly with regard to weight reduction, are the significant or governing ones for each component.

The weight reduction methodology was divided into three sections.

a. Product Dependent Weight (three approaches were used):
   1. Design Modification (Size Reduction),
   2. Redesign (Reduction of Weight by more efficient use of materials), and
   3. Material Substitution (Use of higher strength or lighter specific weight materials - aluminum and plastics).

   The Redesign and Material Substitution weight reductions were determined by means of formulas developed on the basis of acceptable reductions in critical criteria such as stiffness, strength, or a combination of both. Reduction levels were established on the basis of current experimental or production results.

b. Power Dependent Weight:

   Horsepower required for the reduced weight vehicle was established at the same level of performance as current models. Factors based on current experience were established to provide displacement and weight for the new engine. A formula was used, with some modification, to establish the weight reduction for other power dependent items.

c. Weight Dependent Weight:

   A design formula, with some modification, was used to determine the weight reduction for chassis load-carrying components.

Finally, a propagation study was made to optimize the vehicle weight reduction as a result of Power and Weight Dependent reductions. The final weight saving result is:

	VEHICLE TYPE		
	PICKUP	VAN	UTILITY
Product Dependent Weight (lbs.)	-586	-391	-551
Power Dependent Weight (lbs.)	-207	-207	-317
Weight Dependent Weight (lbs.)	-95	-71	-107
TOTAL (lbs.)	-888	-669	-975

Changes in minimum current vehicle weight are:

	PICKUP	VAN	UTILITY
Current Weight (lbs.)	3572	3432	4277
Weight Reduction Potential (lbs.)	-888	-669	-975
Potential Curb Weight (lbs.)	2684	2763	3302

A discussion of the anticipated effects of the weight reduction is provided in Section 6 of this report. Briefly, these are:

A net cost penalty of approximately

+$92.41	for the Pickup,
+$44.36	for the Van,
+$58.86	for the Utility,

can be anticipated. These are basically material cost penalties; final manufacturing costs could be considerably higher depending on difficulties encountered with utilization of large tonnages of new material.

Tooling costs for body components are estimated to be between $100 and $200 million per manufacturer plus additional large expenditures for engine, driveline, and chassis parts if they cannot be common with passenger cars. Additional large sums would also be required for engineering and development.

Serviceability would be improved by use of more 6-cylinder engines, but expanded use of aluminum could cause some handling problems and higher costs. "Lighter trucks" and higher costs might have some temporary negative reaction, but the long range result should be favorable.

The impact on the material suppliers and the truck industry would be extremely great. There is a serious question of whether they would have the capital and technical resources to implement the changes in the period of 1982 to 1985 which overlaps similar extensive changes to passenger cars.

1. INTRODUCTION

The study described in this report identified the Weight Reduction Potential for Light Duty Trucks for the period 1982 - 1985. The scope of the project includes Pickups, Vans and Utility models of 8500 pounds GVWR or less. The weight reduction processes used included Design Modification, Redesign, and Material Substitution. The weight saving by Design Modification results from reduced component size. Redesign savings result from a more efficient utilization of material. The savings from Material Substitution result from selective applications of light weight materials (Aluminum and Plastic) in place of steel and the use of higher strength steels in other selected applications.

The methodology utilized first established the Missions or functional uses required of Light Duty Trucks. The second step consisted of selecting the Attributes considered significant to the satisfactory functional performance of the vehicles. Appropriate makes and types of trucks to be analyzed were then established. The next step consisted of the selection of the specification to define the Attributes. The Attributes were then compared to establish the most efficient design on the basis of functional capacity vs. vehicle weight. Functional efficiences and actual weights were used to establish the most efficient design for each selected vehicle type. The most weight efficient components were used as a "current" base to which the weight reduction techniques were applied. Significant vehicle functions were maintained. These consisted of Load, Volume and Passenger Capacities, and Performance Potential equal to the minimum level provided by current domestic production vehicles.

The Weight Reduction methodology was organized in three parts:

1. Product Dependent Weights
2. Power Dependent Weights
3. Weight Dependent Weights

The product Dependent Weight consists of the basic vehicle structure which contains the passenger and cargo areas. Its size and structural requirements were established by the functional use of the vehicle. Three steps were taken to determine the weight reduction potential:

1. Functional requirements were assessed to determine where the vehicle could be made smaller and the weight saving attributed to the reduced size established.

2. The design criteria for components considered for weight reduction were established, and acceptable reductions in criteria were determined based on recent experience with redesign techniques. Formulas were developed to provide the weight reduction potential of these revised criteria.

3. The same formulas were utilized to provide the weight reduction potential by substituting lighter materials.

Power Dependent Weight reduction was determined by reducing engine power in relation to weight reduction but at a constant performance level. Formulas were utilized to establish the weight saving of the smaller engine and related Power Dependent components.

Weight Dependent Weight saving was established both by formula and by reference to propagation effects on current models when GVWR is increased. The components in this group consist of the suspension, brakes, wheels, and tires, as well as portions of other components which are partially affected by vehicle Product Weight (steering, rear axle, transmission, etc.). Components which were judged to have little weight reduction potential, such as soft trim and electrical parts, were not considered.

The summation of the foregoing weight reductions provided the potential weight reduction for the selected vehicles. Section 6 discusses the effect of weight reduction.

2. VEHICLE IDENTIFICATION AND COMPARISON

2.1 IDENTIFICATION OF MISSIONS

The light duty field covered in this report comprises vehicles produced for a wide range of commercial enterprises as well as for a growing portion of the personal transportation and recreation vehicle markets.

The principal truck missions and their share of the market are shown in Figure 2-1. Since these statistics cover all trucks, the percentage of light trucks used for personal transportation may be even higher. Indications are that this use of trucks is continuing to increase.

2.2 IDENTIFICATION OF ATTRIBUTES

In order to insure that the vehicle weight reduction results of this program do not impair the ability of the vehicles to perform their required missions, it was necessary to establish attributes which are significant to the performance of the missions. There are obviously many attributes which concern and influence the potential purchaser of a light duty truck. The most important of these include:

a. Load Capacity,

b. Volume Capacity,

c. Passenger Capacity,

d. Performance,

e. Durability,

f. Fuel Economy,

g. Engine Type,

h. Transmission Type,

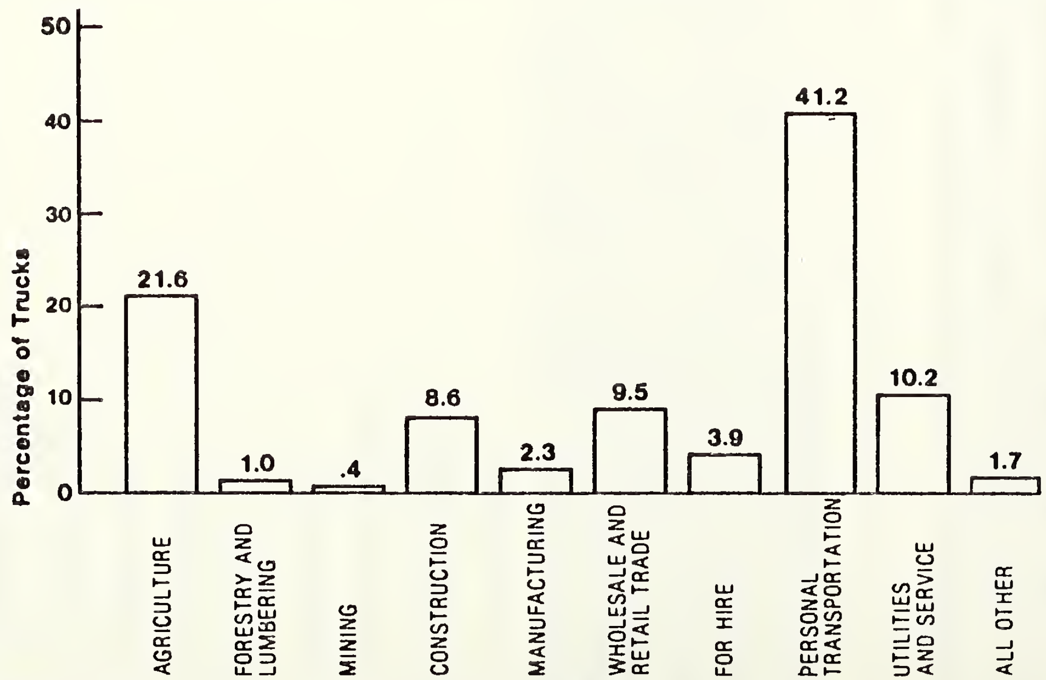
i. Ride and Handling,

j. Options Available,

k. Appearance,

l. Ease of Maintenance, and

m. Cost.



SOURCE: U.S. Bureau of the Census, *1972 Truck Inventory and Use Survey*.

FIGURE 2-1 PRINCIPAL TRUCK MISSIONS

Although a large percentage of light duty trucks are now used primarily for personal transporation, it must be recognized that the basic reason for the existence of the pickup and van is commercial. For many businesses, the initial cost and operating expense of a light duty vehicle vs. heavier models are essential to their profitable operation. The most significant attributes are, therefore, those concerned with the basic commercial missions of the vehicles. These are:

a. Load Capacity,

b. Volume Capacity, and

c. Passenger Capacity.

Load Capacity is defined as the difference between the Gross Vehicle Weight Rating and the Curb Weight of the truck. More specifically, the definition may be expressed as:

a.	Load Capacity where:	= GVWR - Curb Weight
	GVWR (lbs.)	= Gross Vehicle Weight Rating, the maximum overall weight at which the vehicle is designed to operate. GVWR is established by the manufacturer and is the common measure used to classify the various sizes of trucks.
b.	Curb Weight (lbs.)	= Base vehicle weight as specified by the manufacturer. Curb Weight includes only standard equipment (as included in the base price) and full quantities of all fluids.
c.	Load Capacity (lbs.)	= The weight of cargo, driver, passengers, and all extra equipment not included in Curb Weight.

It is important to note that the weight of passengers and any extra equipment provided must be subtracted from the Load Capacity before the true cargo load capacity can be determined. Load Capacity, is therefore, essential to the commercial user who requires an adequate cargo load capacity and to other users to whom passenger capacity or special equipment capability are important. Load Capacity is considered the most important attribute of a light duty truck and will be maintained as a constant while weight reduction efforts are directed at Curb Weight.

Volume Capacity (cu. ft.) cannot be as precisely defined as Load Capacity but is considered to be the space assigned to carrying the cargo load. In a van type (closed) vehicle it is the interior space behind the driver's seat. In a vehicle without a top on the cargo area (Pickup), volume is considered to be the usual manufacturer's specification of volume measured to the top of the permanent sides. It is recognized that specific loads higher than the sides can be carried, but a uniform and generally recognized definition is required.

For carrying many types of cargo, Volume Capacity may be as important as Load Capacity. One common standard for adequate volume seems to be a minimum of four feet (4.0') of clear load space between the rear wheel housings. This is based on the widespread use of this dimension as a unit size for building materials and cargo containers. The availability of a body with an eight foot (8.0') cargo area length (shorter body lengths are offered) is also considered necessary for similar reasons. These dimensions will be maintained in redesigns directed toward Curb Weight reduction.

Passenger Capacity is defined as the number of seating positions designated by the manufacturer. The number of seating positions is important in order to provide for transport of work personnel in cargo vehicles and passengers in a van-wagon type vehicle. Current Passenger Capacities will be maintained in the reduced weight designs. Since all pickup cabs built domestically carry three passengers and will retain that capacity, and since all these cabs have similar dimensions, specific Passenger Capacity comparisons will not be made for pickups.

Retention of current Load, Volume and Passenger Capacities will of course have a limiting effect on the weight reduction potential of light duty vehicles. However, personnel in the truck field, support the position that these attributes need to be maintained for at least a sizeable portion of vehicles in the light duty field. However, there does appear to be a potential for further weight reduction by decreasing the size of some percentage of the vehicles to the so called "compact" size. A procedure comparable to that developed in this study for full size vehicles could be applied to minimize the weight of the compacts. This subject should be considered as a separate study in order to achieve the maximum benefits from the overall weight reduction effort.

Performance Capability, while not considered as significant as Load, Volume and Passenger Capacity, is still a significant attribute to be considered in a weight reduction programs. Since a quantitative evaluation of the effects of reduced performance on the ability of a light duty truck to perform its functional requirements is beyond the

scope of this project, current minimum performance levels will be maintained for the reduced weight vehicles. Reduced performance levels could also have an impact on traffic flow, particularly in urban areas. This should be evaluated before significant reduction in performance levels are advocated.

Performance Capability is commonly measured by:

Acceleration (ft./sec.^{2})	= a measure of the agility of a vehicle in changing from one speed to a higher speed.
Gradeability (%)	= a measure of the capability of a vehicle to negotiate a "grade" which is the slope of the roadway from one elevation to a higher one.

Maximum Tractive Effort (lbs.) is also a significant factor for trucks. It is defined as the maximum force the powertrain can develop at the driving wheel contact with the ground. It is important because of the requirement to start the loaded vehicle on a grade (at a loading dock, for example).

Because of the many variables involved, it is difficult to accurately calculate Acceleration and Gradeability. However, the ratio of Power Available to Gross Vehicle Weight is the dominant factor in these calculations. This is particularly true when vehicles of similar size and configuration are compared in that it provides a reasonable measure of Performance Capability. Therefore, HP/GVWR will be utilized in this report to provide comparable levels of performance of Acceleration and Gradeability between current production and reduced weight proposals.

Tractive Effort, on the other hand, requires more definitive calculations because of the significant influence of engine torque (rather than power) and powertrain elements (transmission and axle ratios, and tire size). Manufacturers' minimum recommendations will be maintained for startup Gradeability.

While considered significant to the performance of the missions, the following "Comfort-Convenience" attributes will be retained for customer satisfaction because they are so well established:

a. Automatic Transmission,
b. Air Conditioning,
c. Power Brakes, and
d. Power Steering.

Since all accessories and options reduce cargo load capacity, the selection of

options appears to be a matter of personal choice determined by the ultimate mission of a particular vehicle. Therefore, the specifications used for attribute comparison and weight reduction analysis are for standard equipment only. A supplemental weight analysis is provided for the special equipment options included in a 33 percent or more usage category used by manufacturers in classifying vehicles for EPA fuel economy inertia weight categories.

In summary, the attributes which will be quantified and compared in this report are:

a. Load Capacity,

b. Volume Capacity,

c. Passenger Capacity (Van and Utility only), and

d. Performance.

2.3 IDENTIFICATION OF VEHICLE CLASSIFICATIONS

The official scope of this project covers a broad classification of "light duty trucks" up to and including 8500 pound GVWR. The 8500 pound limitation conforms to the current EPA classification of fuel economy standards for this class of vehicle.

The light duty field, as it is commonly defined, includes all non-passenger type automotive vehicles up to 10,000 pounds GVWR. A multitude of models of several different makes are included within this broad category, including a variety of specialized vehicles and body types. In order to limit the vehicles considered for the weight reduction potential investigation to a workable number, only those vehicles with a significant percentage of the total volume of this category will be considered. The following list indicates some of the types excluded:

a. Military Vehicles,

b. Off-road (exclusively) Vehicles,

c. Electric Powered Vehicles, and

d. Specialized bodies on a production chassis or chassis and cab (motor homes, emergency and public utility vehicles,etc.)

In most instances, the majority of weight savings achieved on the production portion of these vehicles will also apply to them.

The foregoing exclusions still leave a broad spectrum of vehicles in the so-called "production" category. Appendix A provides an overview of the variety of models offered in this "light duty truck" classification.

It will be noted that five manufacturers are included. This consitutes the extent of domestic companies manufacturing road type (i.e., those designed for highway or combination highway-off road use) production vehicles (i.e., those with any significant volume). GMC is not included, because the vehicles offered are identical to Chevrolet except for name plate and minor trim items. For reference, a brief discussion of the apparent design philosophy of each of the manufacturers is also included in Appendix A.

Examination of the charts in Appendix A indicates that there are three basic types of vehicles:

a. Pickup (Figure 2-2),

b. Van (Figure 2-3), and

c. Utility (Figure 2-4).

The Pickup classification provides the well known open type cargo box as a manufacturers' supplied vehicle. The chassis and cab is also available without the cargo box for those wishing to provide a specialized body. The pickups supplied by the big three manufacturers also have the following options:

A flush-sided cargo box

or

A cargo box within the wheels with external fenders.

Since the flush side box accounts for a high percentage of the production volume it will be considered. It is also the lighter of the production volume it will be the only one considered. It is also the lighter of the two constructions. Futhermore, the flush side box is also offered in 6½ foot and 8 foot lengths. Again, since the 8 foot box constitutes a high percentage of the total volume and is the only size available above the base models (about 6000 pounds GVWR), it was selected as the base for this project. The Pickup classification also includes a choice of three different cabs:

Conventional - two door with single bench seat and three-passenger capacity.

Club - two or four door with three-passenger normal capacity but

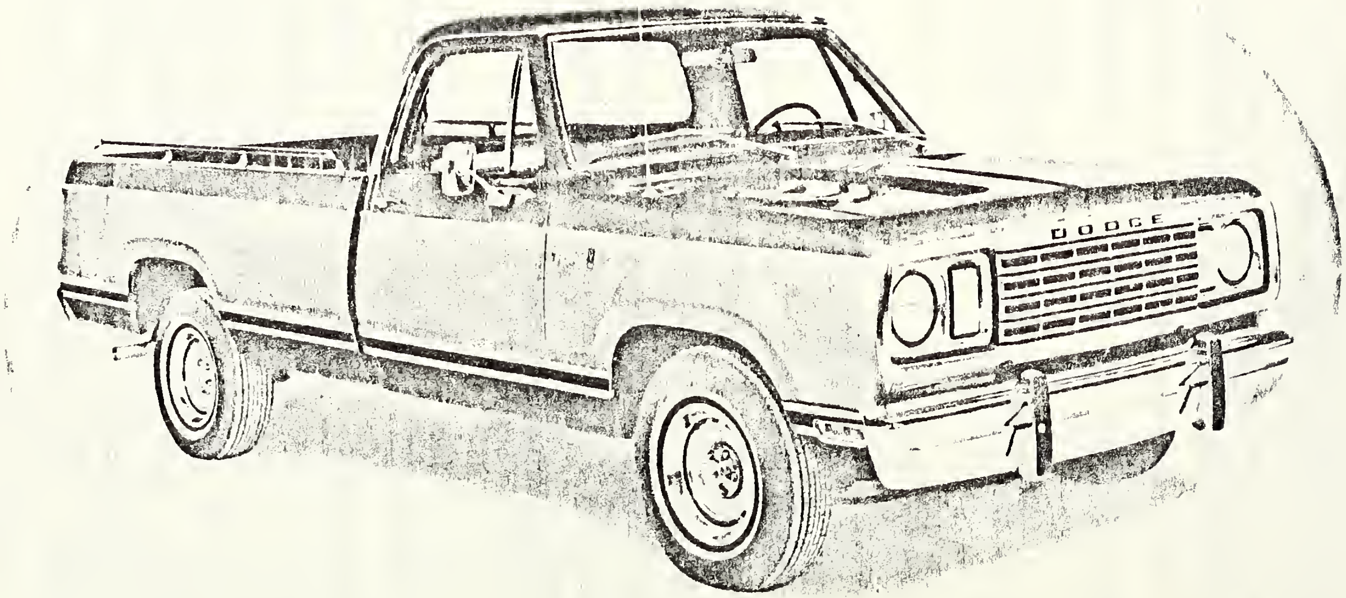


FIGURE 2-2 LIGHT DUTY TRUCK - PICKUP

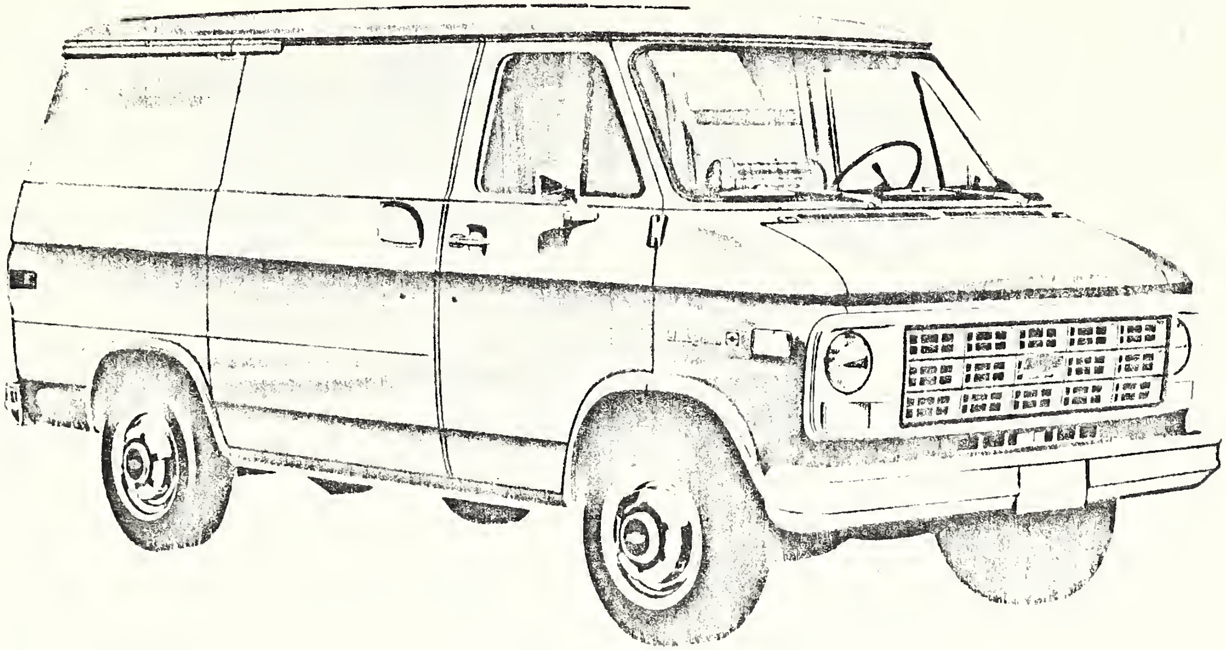


FIGURE 2-3 LIGHT DUTY TRUCK - VAN

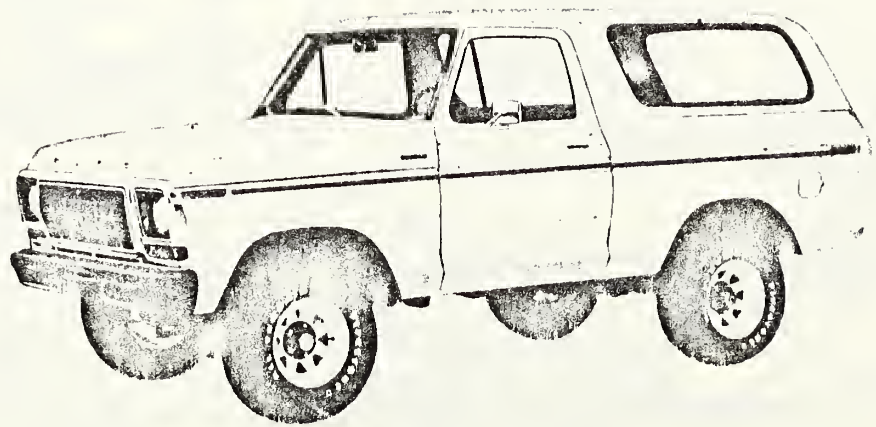


FIGURE 2-4 LIGHT DUTY TRUCK - UTILITY

with added space behind the seat for cargo or additional passenger capacity.

Crew - an extended cab with four instead of two doors and a full width rear seat added for six-passenger capacity.

The specialized cabs use the same cargo boxes as the conventional cab requiring an extended chassis. Since these special cabs constitute a very small percentage of total pickup production and utilize in general the same components except for the rear section of the cab, they will not be separately considered in this study.

The Pickup classification also includes 4-wheel drive models as well as the common 2-wheel drive. Since the 4-wheel drive versions constitute a relatively small percentage of production, and the special chassis and powertrain elements are common with the Utility vehicles, they will not be included in the Pickup classification. The 4-wheel drive components will be covered under the Utility classification.

The Van (Figure 2-3) classification is characterized by a single large volume enclosed body. The driver and optional passenger seat are included in the same body enclosure as the cargo area. Current production vans have a modified or semi-forward control position for driver and passenger located alongside the engine. This is done to reduce overall length and to provide a more compact vehicle. The current designs grew out of the "compact" vans of the early 1960's.

The terminology "Van" is often applied to separate bodies of the enclosed type, mounted on either a "pickup type" cab and chassis or a "van type" forward section. These special body types are not included under the "Van" classification in this study.

There are also forward-control "steps" vans supplied by some manufacturers. These get their name from the low floor in the driver area to facilitate entry and exit for the driver in typical "door to door" delivery missions. The forward control also provides a shorter overall length for easier handling under crowded urban conditions. Since this type of truck represents a small percentage of the light duty field and most models are in the 8500 to 10,000 pounds GVWR class, they will not be included in this report.

The Van classification in this report will include the Van-Wagon type vehicle since it utilizes the same body and chassis as the commercial van. The weight saving potential for the "Van" applies to both type vehicles.

The Utility (Figure 2-4) classification applies to the rather specialized vehicle designed primarily for personal transportation and recreational use. However, in recent years it has achieved a significant volume level and is therefore included in

this study. It is considered a part of the light duty truck fleet because it shares a great many components (front end sheet metal and chassis) with the pickup truck and is designed by truck rather than passenger car criteria. Most vehicles sold in this classification are 4-wheel drive although Chevrolet, Dodge and International also offer 2-wheel drive versions. Only the 4-wheel drive is included in this report.

Unlike the Pickup and Van classifications, the Utility models of the different manufacturers differ in standard equipment supplied with the base vehicle. For purposes of analysis and comparison, all models in this study include a hard top and a passenger front seat, although they are not standard on all models.

One other type not included is the Truck Station Wagon (not the Van-Wagon) offered only by Chevrolet and AMC. These models represent a somewhat specialized and small percentage of the market. Since they share chassis, powertrain and many body components with the Pickup and Utility, they will not be considered separately.

While the weight reduction analysis of this study limits itself to the selected vehicles of domestic manufacturers, a few representative foreign built models are included in the attribute comparison section to provide a feel for the effectiveness of foreign designs in the areas selected for comparison. Foreign models were not included in the weight reduction analysis because a detailed examination of their specifications indicated that they are not comparable with domestic models in one or more of the selected significant attributes. Most foreign models have significantly reduced load and/or volume capacity. They also have performance capabilities considerably below the minimum established for domestic models. Specifications for the following foreign built makes and models were reviewed:

a. European

- Bedford
  - CF
- British Leyland
  - Sherpa 240 and 250
  - Land Rover
  - Range Rover
- Daimler - Benz
  - L206 and L207
  - L306 and L307

- Fiat
  - 238
  - 242
  - 616
- Ford
  - 100 thru 190
  - A0410, 509 and 510
  - L407 and 409
- Peugeot - Citroen
  - C-35
  - J7 and J70
  - 404
- Renault
  - R2136 and 2137
- Volkswagen
  - LT28, 31 and 35

b. Japanese

- Daihatsu
  - 360
  - 550
  - SV17, 18 and 26
  - DV23, 26 and 28
  - F10 and F20
- Honda
  - TN360
- Isuzu
  - KB20 and 25
  - KA41 and 51

- TL23
- Mitsubishi
  - Colt T120
  - Minica
  - Minicab
  - Canter
- Nissan (Datsun)
  - Datsun 1200 and 1500
  - Datsun C20
  - Nissan E20
  - Nissan Homer
  - Nissan Junior
  - Nissan Clipper
  - Nissan Caball
  - Nissan Patrol
- Subaru
  - 360
  - 500
- Suzuki
  - L60 and L60V
  - ST20
  - LJ50
- Mazda
  - 1000 and 1200
  - B1600
  - F1000
  - D1500

E2600 and 2700

Toyota

1000

Hi-Lux

Stout

Hi-Ace

Toyo-Ace

Dyna

Land Cruisers

In summary, the classifications of vehicles included in this study are:

a. Makes:

AMC(Jeep)

Chevrolet (GMC, same)

Dodge

Ford

International

b. Types:

Pickup

Van

Van Wagon

Utility (4-wheel drive)

c. Range

Up to 8500 pounds GVWR

As indicated in Figure 2-5, the above selected types constitute approximately 91 percent of the vehicles in the light duty field up to 10,000 pounds GVWR. Since most of the "multi-stop" vehicles and a large percentage of the "other body types" fall in the 8500-10,000 pounds GVWR range, the percentage of the selected types is even higher in the range up to 8500 pounds GVWR.

Body Type	6,000 & less	6,001-10,000	10,001-14,000	14,001-16,000	16,001-19,500	19,501-26,000	26,001-33,000	Over 33,000	Total
Pickup	960,520	699,702	•	•	•	•	•	•	1,660,222
General Utility	92,040	162,592	•	•	•	•	•	•	254,632
Van	189,563	301,286	•	•	•	•	•	•	490,849
Multi-Stop	—	33,882	19,281	66	908	—	—	—	54,137
Station Wagon (on truck chassis)	291	113,771	•	•	•	•	•	•	114,062
Buses (Including school bus chassis)	—	—	—	—	103	28,673	1,322	3,703	33,801
Other Body Types	5,387	78,280	3,163	4	10,405	136,123	23,639	114,345	371,346
Total	1,247,801	1,389,513	22,444	70	11,416	164,796	24,961	118,048	2,979,049

SOURCE: Motor Vehicle Manufacturers Association of the U.S., Inc.

FIGURE 2-5 DISTRIBUTION OF TRUCK SALES BY SIZE - 1976

2.4 SELECTION OF SPECIFICATIONS TO DEFINE ATTRIBUTES

Specification data were obtained from Manufacturer's Truck Data Books and Body Builder's Books also supplied by the vehicle manufacturers. All data selected were for the 1978 models.

For the makes and types of vehicles previously selected, the following data were obtained and tabulated:

- Model Designation
- GVWR (lbs.)
- Wheelbase (in.)
- Curb Weight (lbs.)
- Cargo Area Volume (cu. ft.)
  - Length (in.)
  - Width (in.)
  - Height (in.)

From the above data, Load and Volume Capacity calculations were made and recorded. Passenger Capacity and, in some cases where provided, Load and Volume Capacity were obtained directly from the Data Books.

All data including Load, Volume and Passenger Capacities are tabulated in Appendix B.

2.5 ATTRIBUTE COMPARISON (LOAD, VOLUME AND PASSENGER CAPACITY)

The quantification of the attributes of Load, Volume and Passenger Capacity provides a means of comparing the effectiveness of the vehicle designs by relating the Capacity to the Curb Weight of each model.

The following ratios were therefore calculated and recorded:

$$\text{Load Efficiency} = \frac{\text{Load Capacity (lbs.)}}{\text{Curb Weight (lbs.)}}$$

$$\text{Volume Efficiency} = \frac{\text{Volume Capacity (cu. ft.)}}{\text{Curb Weight (lbs.)}}$$

$$\text{Passenger Efficiency} = \frac{\text{Passenger Capacity (no.)}}{\text{Curb Weight (lbs.)}}$$

The Efficiencies are recorded on the same data sheets with the Capacities. See Appendix B.

2.5.1 Load Efficiency Comparisons

To more effectively present the extensive amount of numerical data graphic displays have been prepared which compare the attributes of the various makes and types of vehicles. The Load Efficiencies are displayed graphically in Figures 2-6, 2-7 and 2-8. The values are grouped by make, model and wheelbase. Each bar represents a GVWR for that group.

The pickup comparison (Figure 2-6) indicates that Dodge has the most efficient design of the models manufactured domestically, based on this method of comparison. AMC is not included in the Pickup chart because their pickup models are 4-wheel drive and are not directly comparable (a special comparison will be provided later in the report). International does not have a comparable model either. The imported compact models of Chevrolet and Ford Pickups (Luv and Courier) are included for comparison as are the specialized passenger car derivatives (El Camino and Ranchero). These models should not be directly compared as will be explained later in the comparison.

Van models are compared in Figure 2-7. There are no comparable imported vans. The Volkswagen is an obsolete design with forward seating positions for driver and passenger which are not compatible with U. S. safety standards. The Load Efficiencies for vans are not as consistent between makes as is the case for pickups. This is partly the result of less consistency between GVWRs for comparable models. For a given design, GVWR can be increased significantly without a corresponding increase in Curb Weight. By using minimum GVWR models for comparison, as was done for the pickup, the considerably heavier Ford appears to be the most efficient. However, it should be noted that the Ford also has a much higher GVWR than Dodge. Since all of the three makes have approximately the same cargo volume, the comparison should be made between models having a more nearly equal GVWR. This comparison is indicated by the cross-hatched bars in Figure 2-7. On this basis, the Dodge is the most efficient. A review of other models at higher but comparable GVWRs confirms the higher efficiency of the Dodge.

Load Efficiencies for the Utility vehicles are difficult to compare (Figure 2-8) because of the wide range of vehicle sizes. Among directly comparable vehicles, the Chevrolet and Dodge are the same for 4-wheel drive models. The smaller Ford and

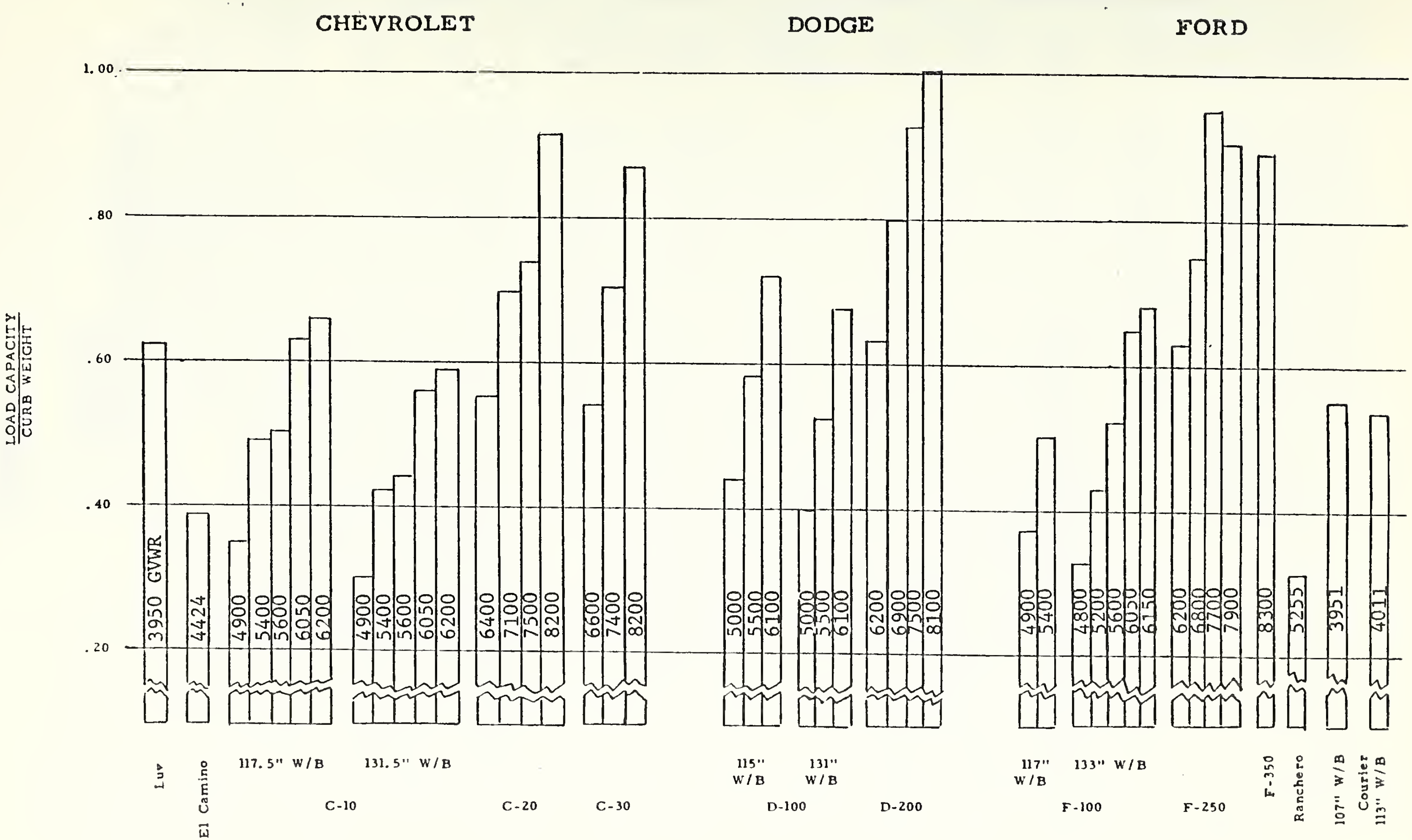


FIGURE 2-6 LOAD EFFICIENCY - PER GVWR. LIGHT DUTY TRUCKS - PICKUP

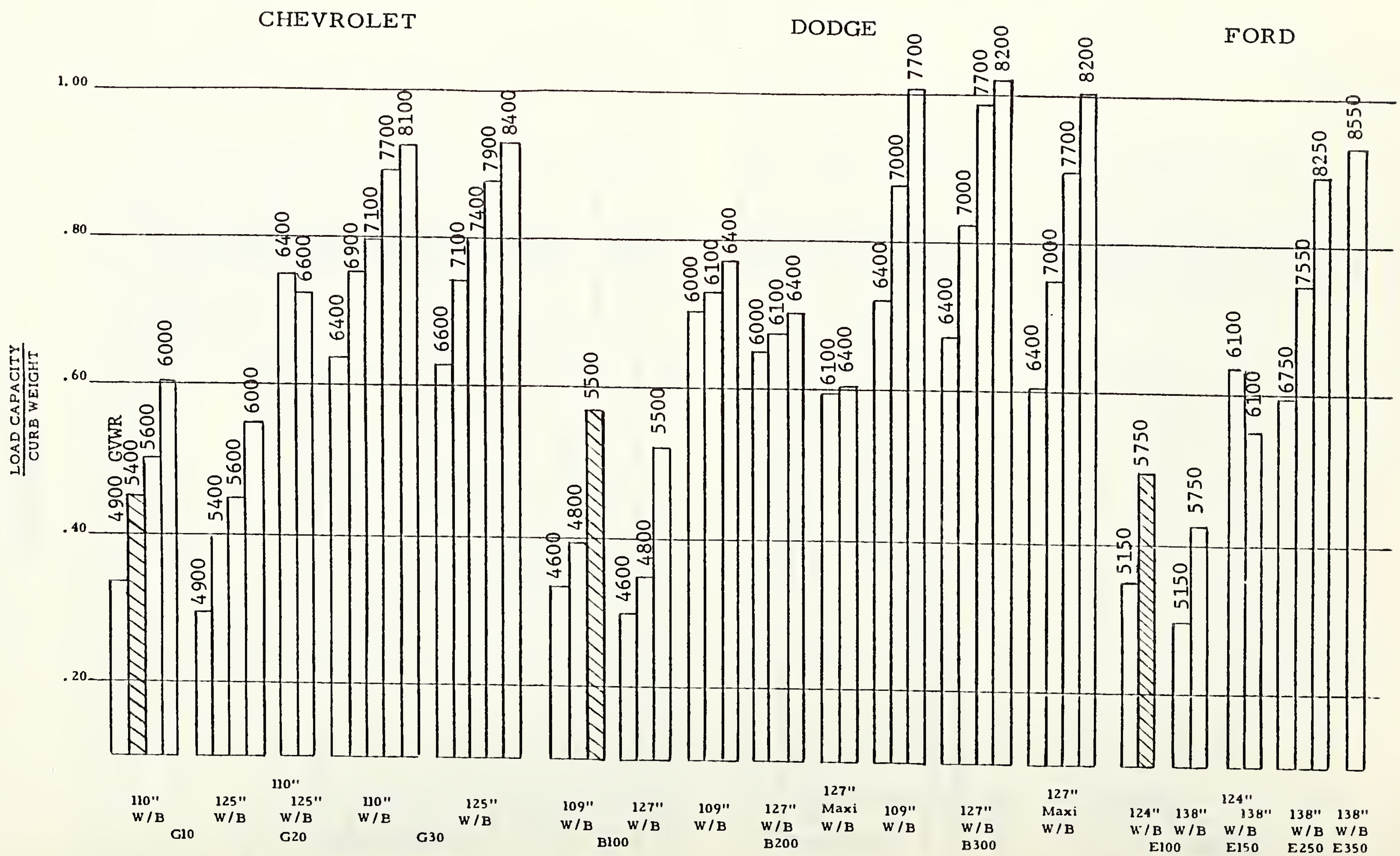


FIGURE 2-7 LOAD EFFICIENCY - PER GVWR. LIGHT DUTY TRUCKS - VAN

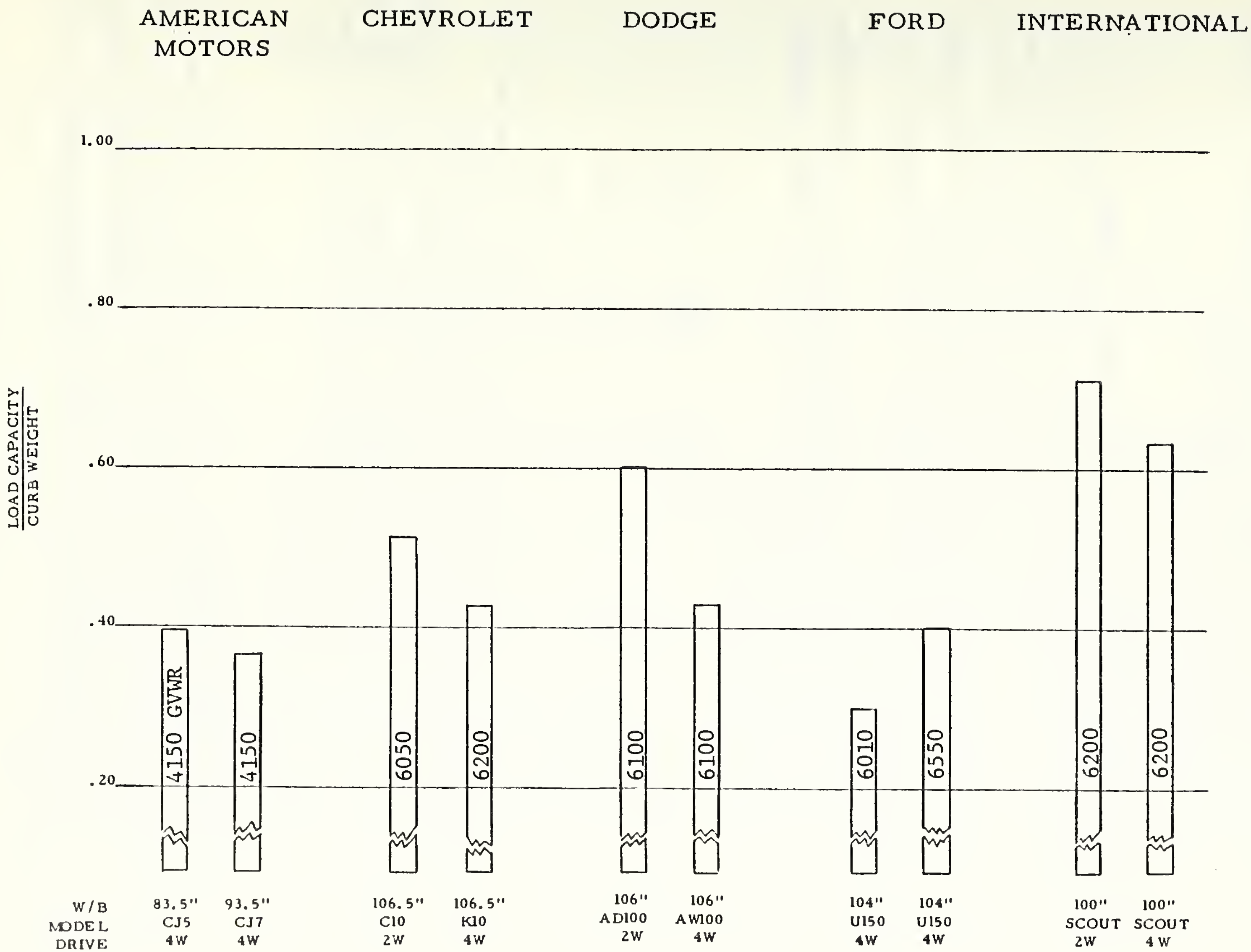


FIGURE 2-8 LOAD EFFICIENCY - PER GVWR. LIGHT DUTY TRUCK - UTILITY

AMC models are less efficient. The International is the most efficient, but its Curb Weight/GVWR ratio is not the same (0.6 vs. 0.7 for Chevrolet and Dodge). Therefore, a direct comparison is questionable. The Curb Weight/GVWR ratio is another means of establishing the most comparable models for comparing efficiencies. It will be discussed in more detail in connection with compact models.

2.5.2 Volume Efficiency Comparisons

Similar Volume Efficiency comparison charts are shown in Figures 2-9 and 2-10. There is no significant change in Volume Efficiency with increase in GVWR since the volume is a constant for a comparable size vehicle. There is also no significant difference in Volume Capacity between the different makes of domestic pickups and vans. It is important to note that the volume of the compact pickups is substantially less than the full size models and, therefore, should not be directly compared because they cannot perform equivalent tasks.

The charts indicate that Dodge is the most efficient pickup design with a less clearly defined difference between Vans because of a difference in GVWRs. Selecting models with GVWRs as close as possible gives:

	Chevrolet	Dodge	Ford
GVWR	4900	4800	5150
Volume Efficiency	0.337	0.389	0.357
Curb Weight/GVWR	0.75	0.72	0.74

The Curb Weight/GVWR ratio is proportional to the Efficiency differences. The Dodge is selected as the most efficient based on the foregoing comparison.

Graphical comparisons are not provided for the Volume Efficiencies of the Utility vehicles because volume is not particularly significant. This is because Utility vehicles are not basically commercial vehicles, and the design sizes are significantly different, so direct comparisons would be questionable.

2.5.3 Passenger Efficiency Comparisons

Passenger efficiencies are shown in Figures 2-11 and 2-12. Comparisons were considered significant only for the multi-passenger models of Van-Wagon and the Utility vehicles. Efficiencies were established on the basis of the maximum seating capacity specified for each model by the manufacturer even though special equipment seating packages were involved.

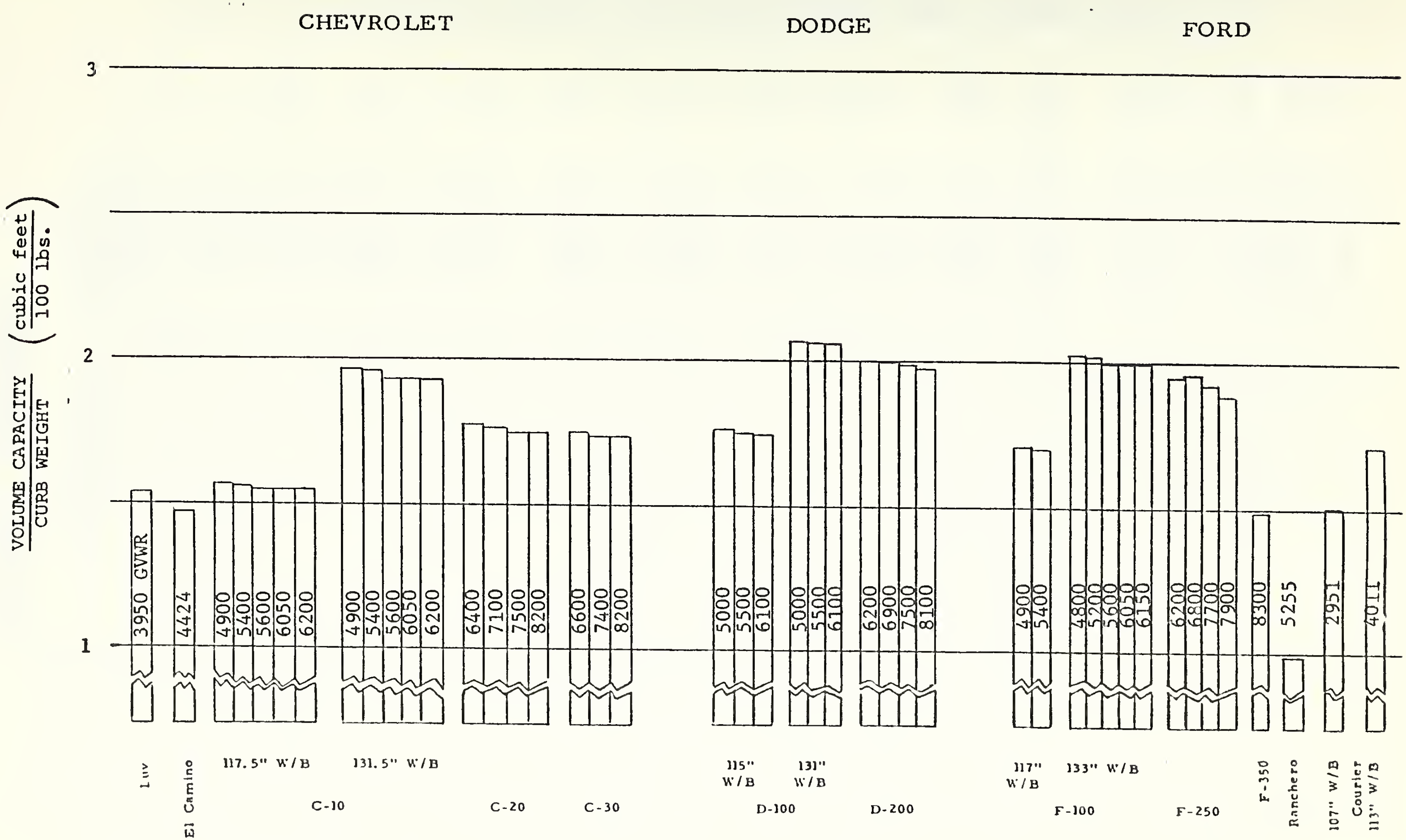


FIGURE 2-9 VOLUME EFFICIENCY - PER GVWR, LIGHT DUTY TRUCKS - PICKUPS

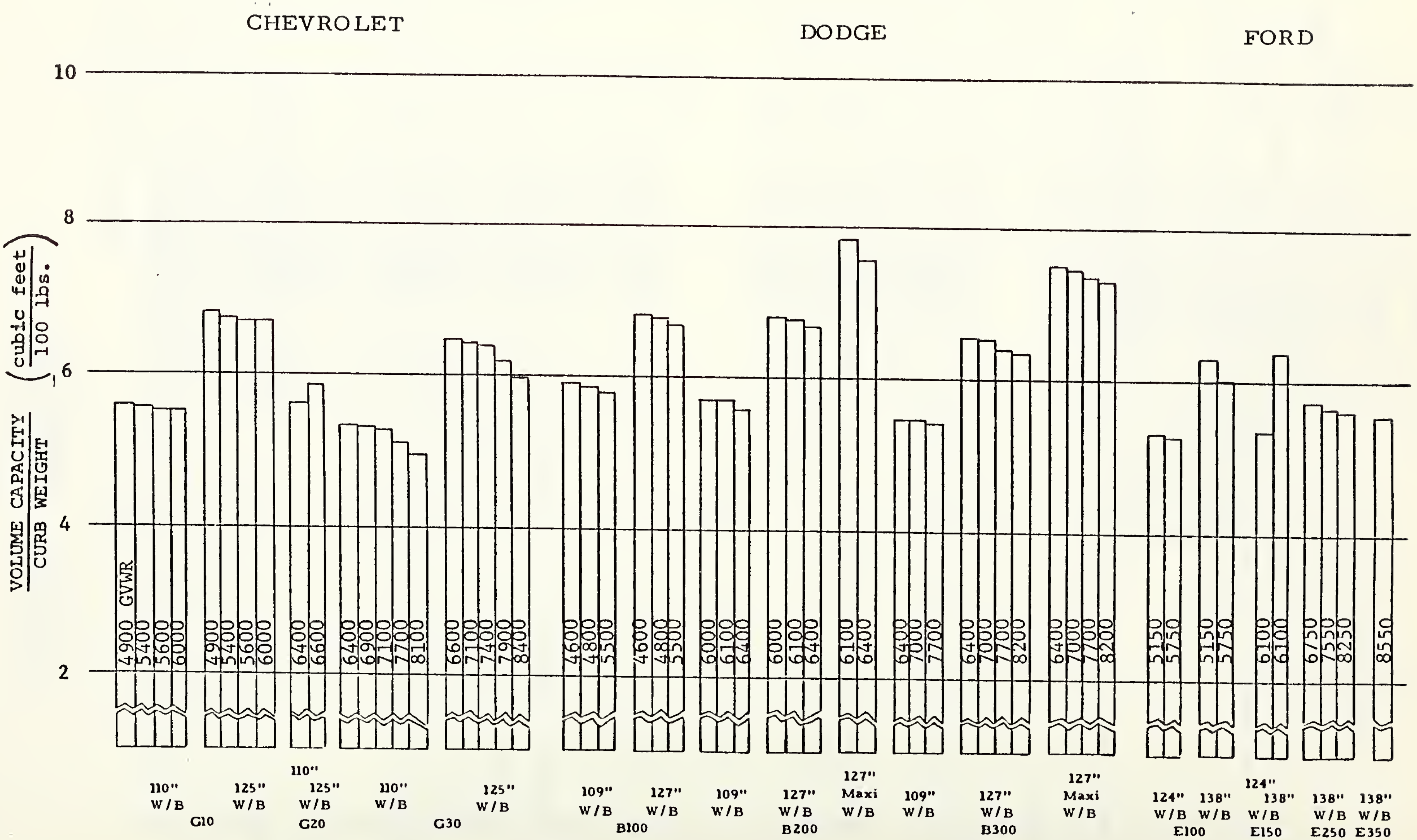


FIGURE 2-10 VOLUME EFFICIENCY - PER GVWR·LIGHT DUTY TRUCKS - VAN

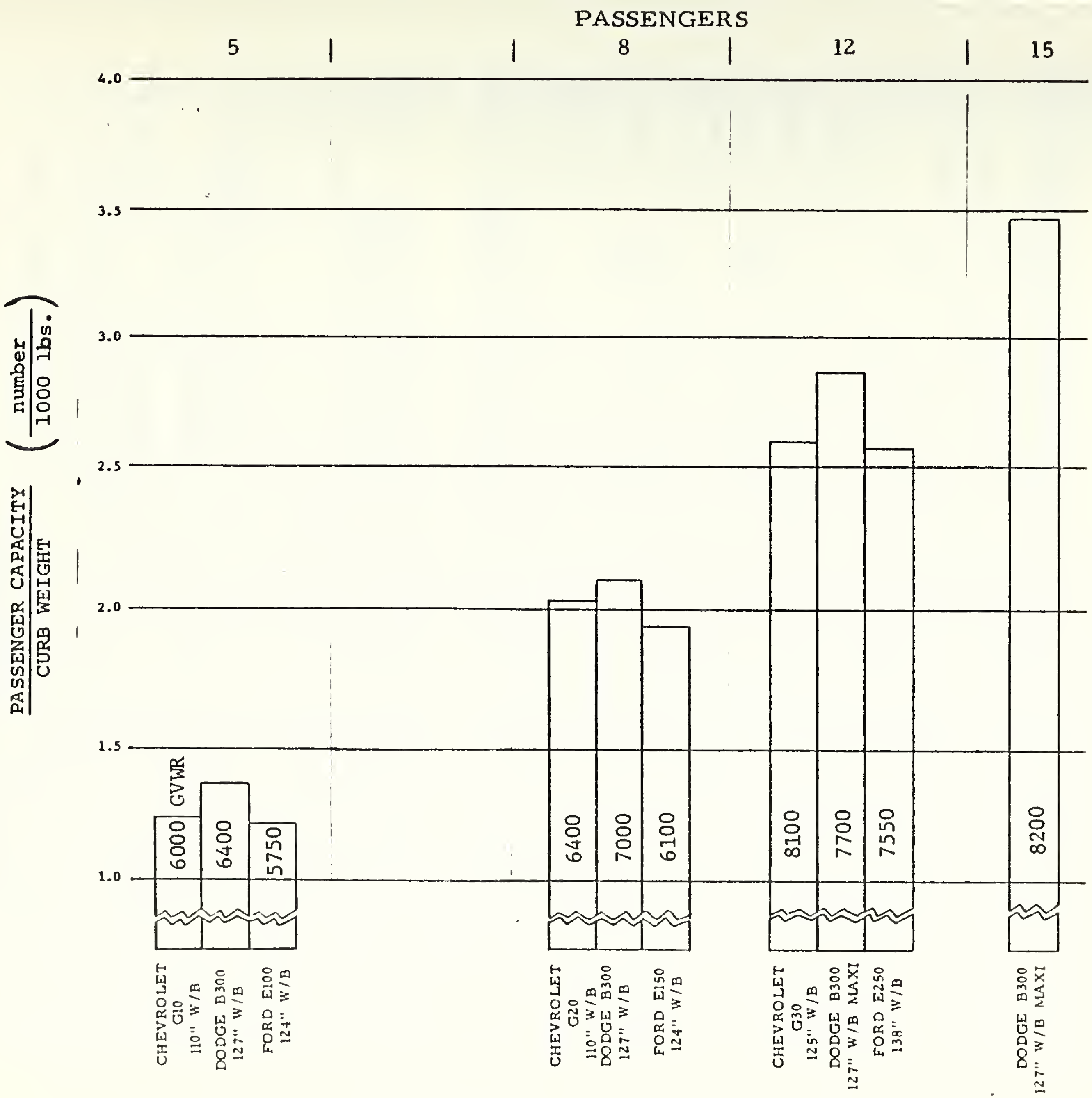


FIGURE 2-11 PASSENGER EFFICIENCY LIGHT DUTY TRUCKS - VAN WAGON

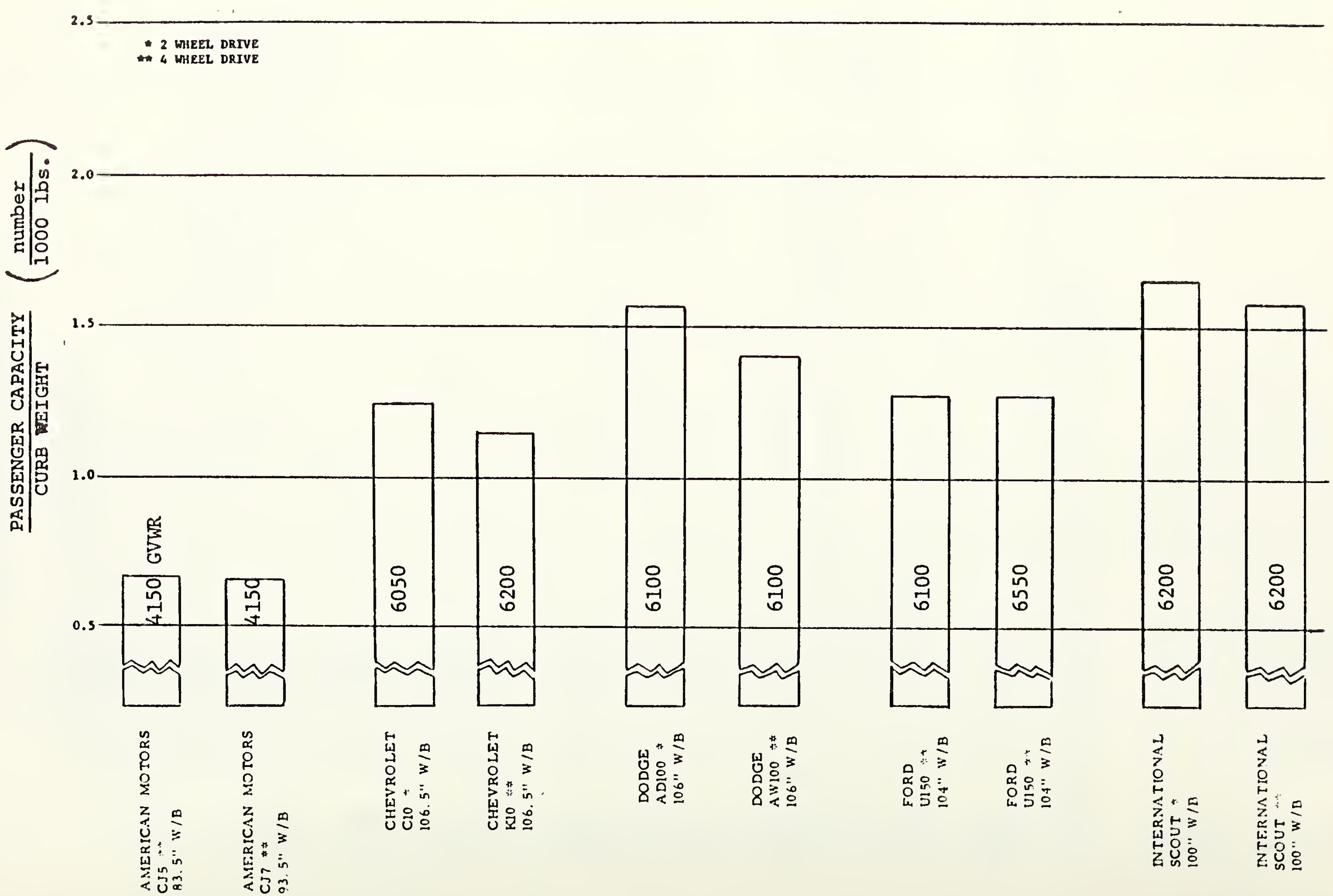


FIGURE 2-12 PASSENGER EFFICIENCY. LIGHT DUTY TRUCKS - UTILITY

The values indicated that the Dodge Van is the most efficient for each of the passenger capacities. The Dodge "Maxi-Van," which is an extension of the body without increase in wheelbase, provides for an extra 3 passenger (15 total) and high efficiency. The Utility Passenger Efficiencies indicate the International to be the most efficient. As previously indicated, it is also smaller than the Chevrolet and Dodge. The AMC Jeep is not comparable because it only accommodates two passengers.

2.5.4 Supplemental Comparisons

Because of the large amount of data involved, several additional charts have been prepared to present the most significant comparisons.

2.5.4.1 Load and Volume - Domestic Pickups - Figure 2-13 compares the basic lowest GVWR Pickup models of the three large domestic manufacturers. These models are generally representative of the comparative efficiency of the designs despite a slight difference in the Curb Weight/GVWR ratios. Since the Volume Efficiencies are essentially the same, the higher Load Efficiency of the Dodge is a meaningful value. For reference, the absolute values of Curb Weight, Load and Volume Capacities for the same models are shown in Table 2-1. Again, the absolute vales for Volume are essentially the same but the Dodge has substantially higher Load Capacity and lower Curb Weight. Since the vehicles are essentially the same size, Table 2-2, and there are no basic design differences (except front suspension), the lighter weight of the Dodge appears to be the result of small differences in most components.

2.5.4.2 Load And Volume - U. S. vs. Imported Compact Pickups - A comparison between the most efficient U. S. conventional size pickup (Dodge) and representative foreign captive import models is shown in Figure 2-14. The shorter 115-inch wheelbase Dodge model is used for this comparison because it is closer to the cargo box length of the compacts. The Chevrolet Luv and Ford Courier are also representative of the imported Datsuns and Toyotas, and other domestic Japanese designs.

The validity of the comparison between these foreign built models and the lowest GVWR model of a domestic series is questionable. Figure 2-15 illustrates the rise in Load Efficiency with higher GVWR in a family of models of the same basic design. This relationship exists because only the load-dependent components of the curb weight, such as the springs, brakes, wheels and tires, etc., are changed to increase the GVWR,

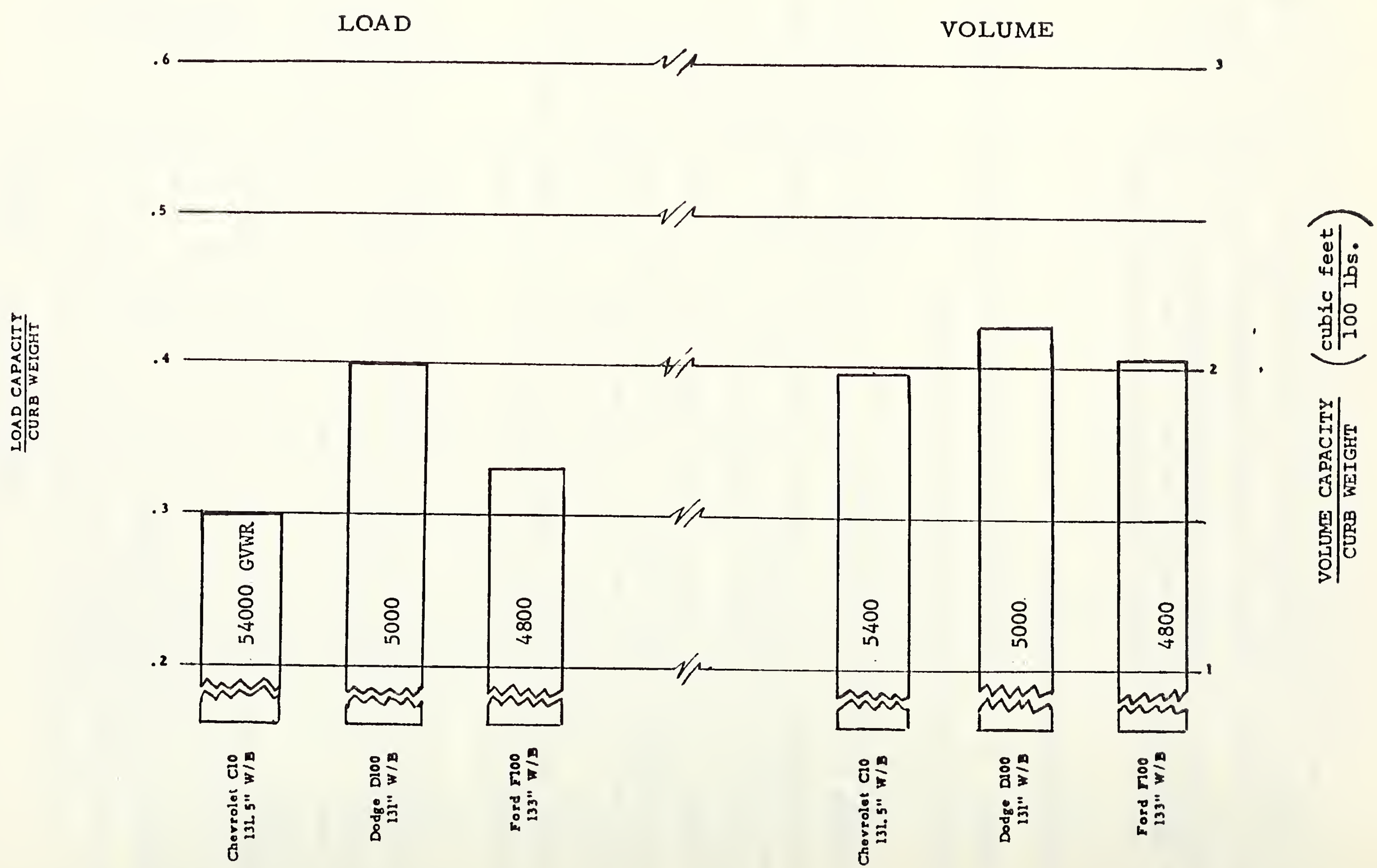


FIGURE 2-13 LOAD AND VOLUME EFFICIENCIES. LIGHT DUTY TRUCKS - PICKUP (DOMESTIC)

TABLE 2-1 CURB WEIGHT, LOAD AND VOLUME CAPACITY COMPARISON,

CONVENTIONAL PICKUP

	CHEVROLET C-10 131.5" W/B	DODGE D-100 131" W/B	FORD F-100 133" W/B
Curb Weight (Lbs.)	3778	3580	3625
Load Capacity (Lbs.)	1122	1420	1175
Volume Capacity ($Ft.^3$)	74.3	76.6	73.6

TABLE 2-2 DIMENSIONAL COMPARISON,

CONVENTIONAL PICKUP

	CHEVROLET	DODGE	FORD
Wheelbase (In.)	131.5	131.0	133.0
Overall Length (In.)	211.4	210.2	211.3
Width (In.)	79.6	79.5	79.1
Height (In.)	69.8	67.8	70.9
Cargo Box			
Length (In.)	98.1	98.0	98.2
Width (In.)	72.0	70.0	70.0
Height (In.)	19.5	19.1	19.3
Between Wheels (In.)	50.0	51.0	50.8

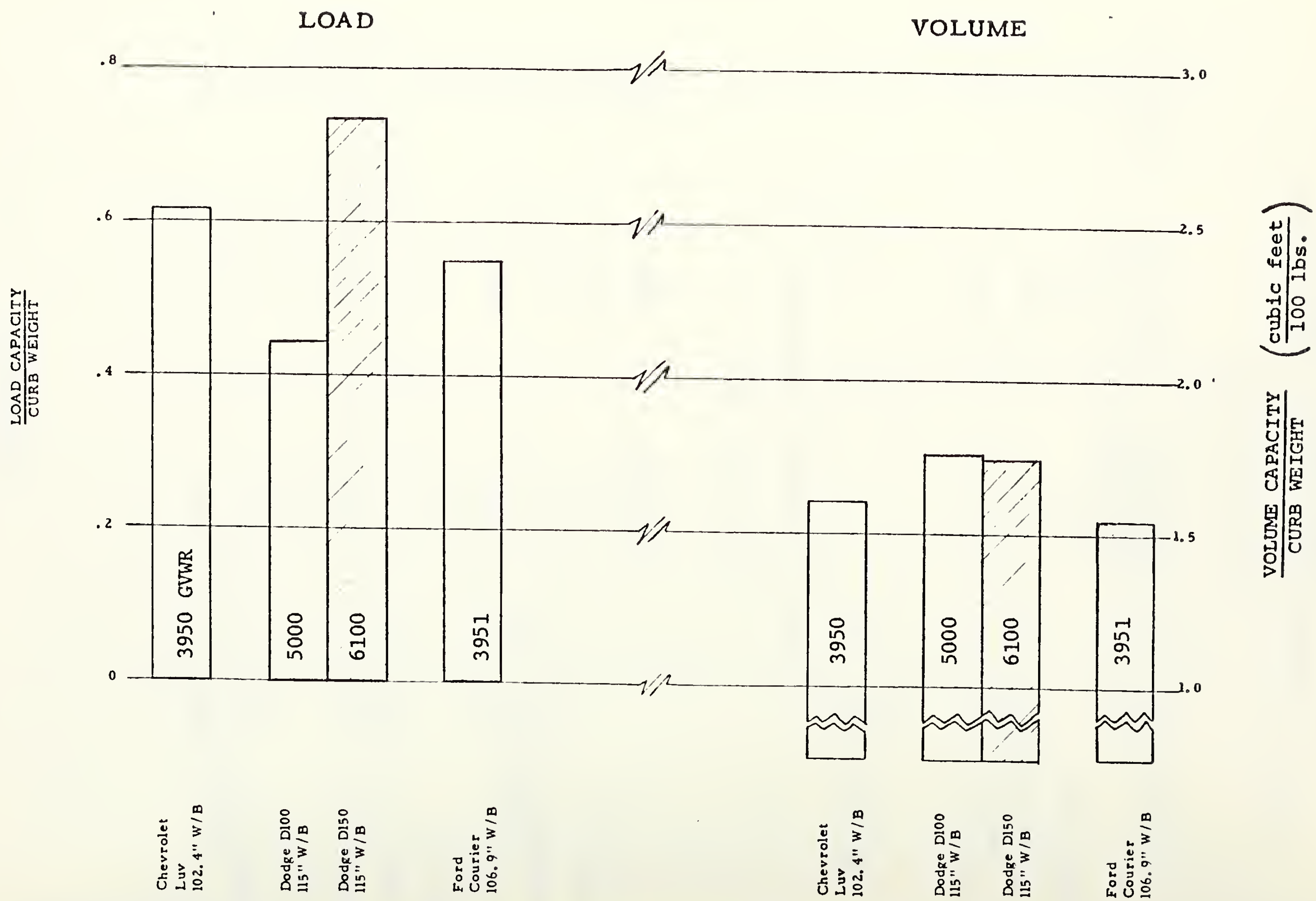


FIGURE 2-14 LOAD AND VOLUME EFFICIENCIES. LIGHT DUTY TRUCKS (DOMESTIC VS. IMPORTS)

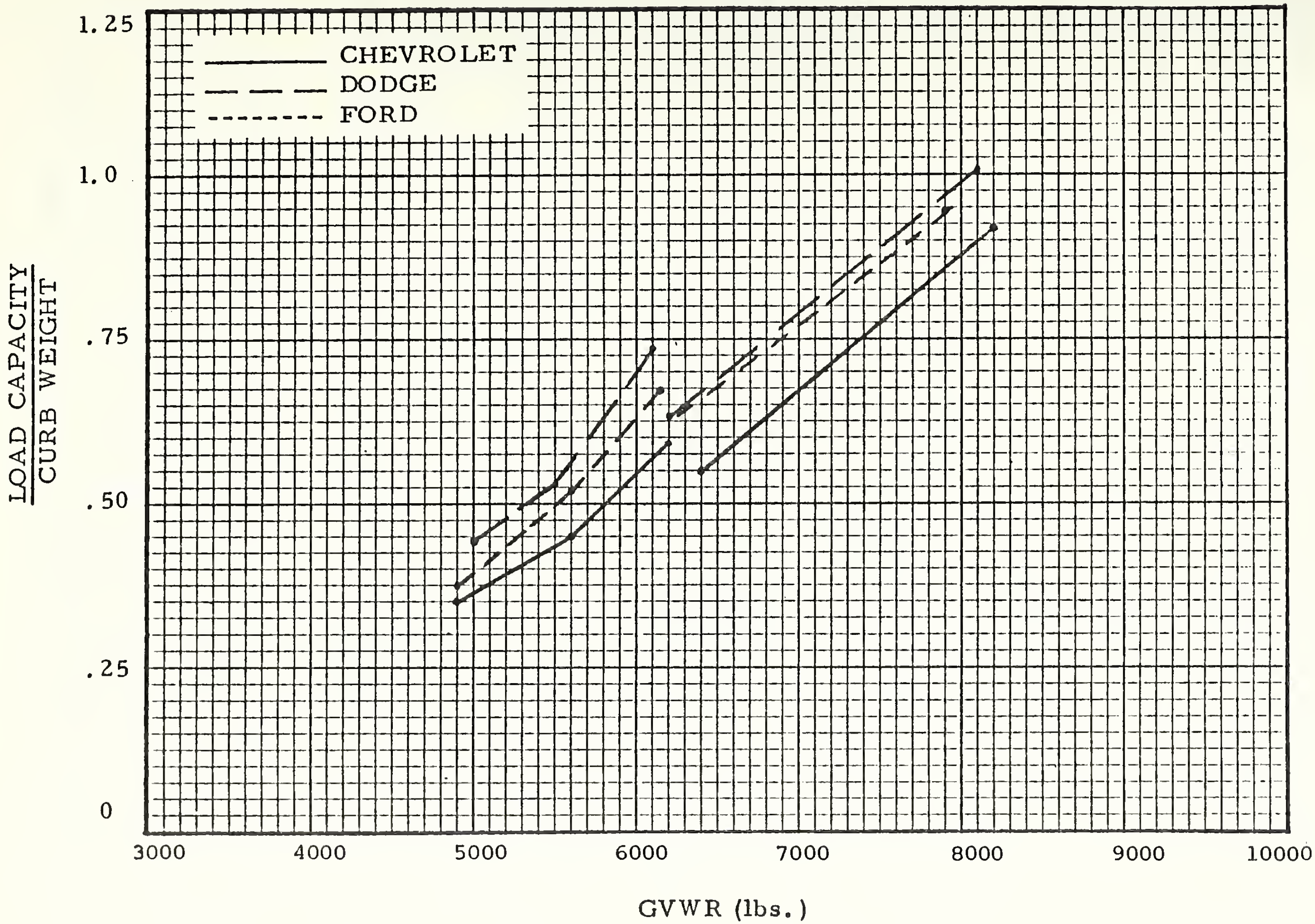


FIGURE 2-15 LOAD EFFICIENCY VS. GVWR - PICKUP

and the increase in their weight is only a small percentage of the increase in GVWR. Other components of the basic design (cab, front sheet metal, cargo box, etc.) are common for all GVWR's. Since the basic design concepts of the compacts (separate frame, cab and cargo box) are similar to the domestic models, a means of establishing a more representative comparison would be by use of similar Curb Weight/GVWR ratios. If a Dodge model with the same Curb Weight/GVWR ratio as the Luv were selected for comparisons:

$$\text{Luv } \frac{2440}{3950} = 0.6$$

$$\text{Dodge D150 } \frac{3635}{6100} = 0.6$$

then, the Load and Volume Efficiencies of the Dodge would be as shown by the shaded bars (Figure 2-14). This indicates that the domestic model has a more efficient design based on this modified basis of comparison.

It is interesting to note, as shown in Table 2-3, that the Luv carries nearly the same payload as the Dodge at about 1000 pounds less Curb Weight. However, this can be misleading unless a representative base for comparison is established as discussed above. The size of the compact truck is also significantly less as shown in Table 2-4. This size vehicle, therefore, cannot be considered as a functional replacement for the current conventional size domestic manufactured pickup.

2.5.4.3 Load and Volume - 4-Wheel Drive Pickups - Although 4-wheel drive pickups are not included in the weight reduction analysis, for reference, an AMC Jeep pickup is compared to a comparable Dodge 4-wheel drive model in Figure 2-16. The Dodge is slightly superior in Load Efficiency and the makes are equal in Volume Efficiency. Actual Curb Weights are very close (Table 2-5) and the Dodge has a slightly greater Load Capacity. Table 2-6 shows the vehicles to be approximately equal in size although the Dodge has slightly more length and width in the cargo box.

2.5.4.4 Load and Volume - U. S. vs. Foreign Pickup - A direct comparison between U.S. built conventional pickups and foreign models is not appropriate because the European and Japanese markets do not have a directly comparable model. European trucks with an open cargo box are either derivatives of a forward control van or have a platform cargo body (over the wheels) with low sides that are usually hinged. The van derivatives generally have the seating position ahead of the wheels, which is not

TABLE 2-3 CURB WEIGHT, LOAD AND VOLUME CAPACITY COMPARISON,

U.S. CONVENTIONAL vs IMPORTED COMPACT PICKUP

	DODGE D-100	CHEVROLET LUV	FORD COURIER
Curb Weight (Lbs.)	3465	2440	2551
Load Capacity (Lbs.)	1535	1510	1400
Volume Capacity (Ft.^{3})	61.1	38.0	38.4

TABLE 2-4 DIMENSIONAL COMPARISON,

U.S. CONVENTIONAL vs IMPORTED COMPACT PICKUP

	DODGE D-100	CHEVROLET LUV	FORD COURIER
Wheelbase (In.)	115.0	102.4	106.9
Overall Length (In.)	190.2	173.8	177.9
Width (In.)	79.6	63.0	63.0
Height (In.)	69.8	59.3	61.5
Cargo Box			
Length (In.)	78.0	73.0	75.0
Width (In.)	70.0	57.5	61.4
Height (In.)	19.1	15.6	16.1
Between Wheels (In.)	51.0	39.4	38.6

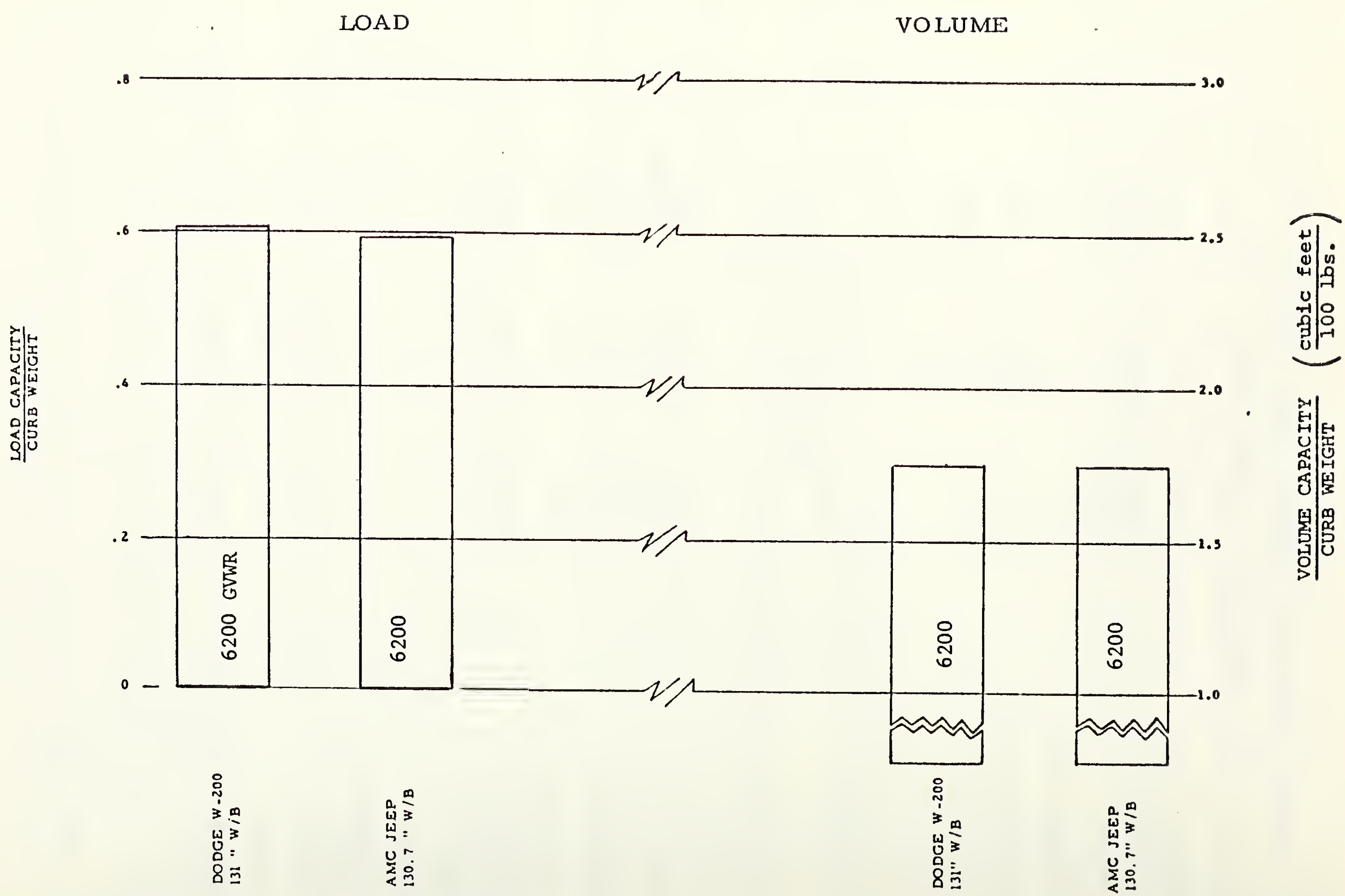


FIGURE 2-16 LOAD AND VOLUME EFFICIENCIES. LIGHT DUTY TRUCKS - FOUR WHEEL DRIVE PICKUP

TABLE 2-5 CURB WEIGHT, LOAD AND VOLUME CAPACITY COMPARISON, DODGE vs AMC (JEEP) PICKUP

	DODGE W-200	AMC
Curb Weight (Lbs.)	4295	4269
Load Capacity (Lbs.)	2605	2531
Volume Capacity (Ft.^{3})	76.6	76.6

TABLE 2-6 DIMENSIONAL COMPARISON, DODGE vs AMC (JEEP) PICKUP

	DODGE W-200	AMC
Wheelbase (In.)	131.0	130.7
Overall Length (In.)	210.2	204.5
Width (In.)	79.5	78.9
Height (In.)	67.8	69.1
Cargo Box		
Length (In.)	98.0	95.6
Width (In.)	70.0	68.0
Height (In.)	19.1	20.5
Between Wheels (In.)	51.0	49.75

considered acceptable for front impact safety in the U.S. (Early U.S. compact vans had this type of layout.) The platform body is comparable to U.S. platform or stake bodies on a light truck cab and chassis, but not to a conventional pickup, although they do provide for additional cargo area vs. a pickup of the same size. Japanese domestic models are either comparable to the Imports (Luv and Courier), similar to European models, or so small they cannot be realistically compared to the conventional U.S. pickup. Furthermore, the mini-pickups of Japan appear to have designs similar to the larger imported models and further comparison would not be productive.

However, one European van derivative does have a U.S. van type seating position (forward control but not ahead of wheels) and for reference it will be compared with a domestic pickup of similar GVWR and Curb Weight/GVWR ratio. The vehicle is a Citreon Fiat produced jointly by both manufacturers for the European market. It is produced in both pickup and van versions. Unlike U.S. Pickups, the C-F model is a derivative of the van with the same forward control seating position (similar to U.S. vans), and uses the same basic unitized structure but without a roof over the cargo area. The conventional Dodge pickup selected as most suitable for comparison is a D-200 131-inch wheelbase model. The basis for selecting the D-200 is shown below:

	Dodge D-200	Fiat 242-15
GVWR	6900	6600
$\frac{\text{Curb Weight}}{\text{GVWR}}$	0.56	0.52

As noted in the discussion relative to imported pickups, it is important to compare vehicles with similar Curb Weight/GVWR ratios if a fair comparison is to be achieved.

Table 2-7 provides a Curb Weight, Load and Volume Capacity comparison while Table 2-8 gives a dimensional comparison of the two vehicles. A comparison of Load and Volume Efficiencies is presented in Figure 2-17. The Fiat shows a significantly greater Load Efficiency (approximately 25 percent). Volume Efficiency is also greater although this higher value is partially due to the use of higher sides, a rather arbitraty design variation although it may be necessary because of the unitized structure. The apparently more efficient design is partially offset by the low performance of the vehicle by U.S. standards, as indicated by the low power to weight ratio. This aspect will be discussed in more detail in the Section on Performance.

While a more powerful and heavier engine would decrease the efficiency advantage of the Fiat, it would not account for the large differential. The major design advantage of the Citreon-Fiat appears to be the use of a unitized structure derived from the

TABLE 2-7 CURB WEIGHT, LOAD AND VOLUME CAPACITY COMPARISON,

U.S. CONVENTIONAL vs EUROPEAN UNITIZED PICKUP

	DODGE D-200	FIAT 242/15
Curb Weight (Lbs.)	3480	3300
Load Capacity (Lbs.)	3060	3300
Volume Capacity ($Ft.^3$)	76.6	127.1

TABLE 2-8 DIMENSIONAL COMPARISON,

U.S. CONVENTIONAL vs EUROPEAN UNITIZED PICKUP

	DODGE D-200	FIAT 242/15
Wheelbase (In.)	131.0	126.0
Overall Length (In.)	210.2	195.3
Width (In.)	79.5	78.3
Height (In.)	70.4	92.8
Cargo Box		
Length (In.)	98.0	118.3
Width (In.)	70.0	70.5
Height (In.)	19.1	27.8
Between Wheels (In.)	51.0	51.2

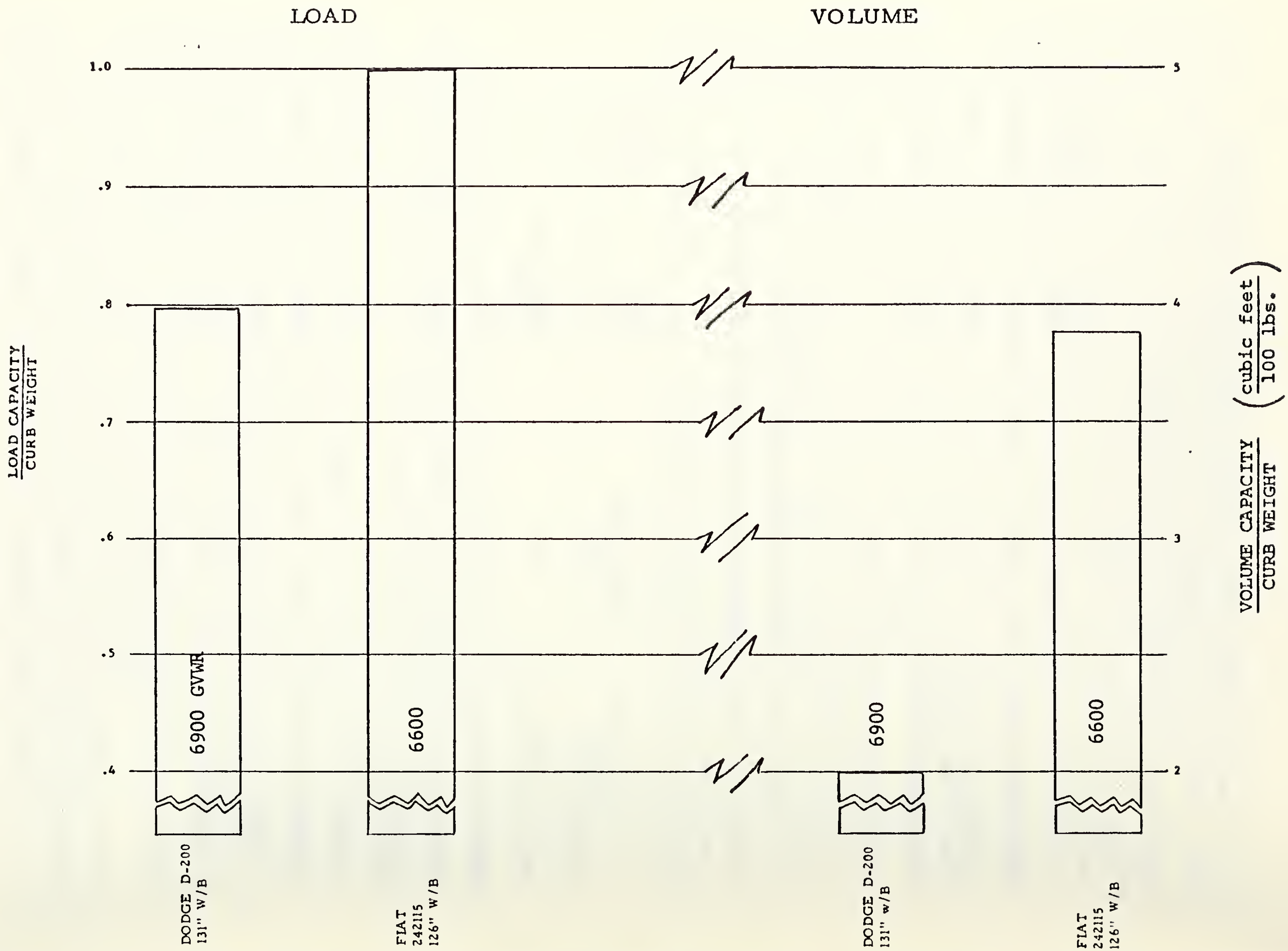


FIGURE 2-17 LOAD AND VOLUME EFFICIENCIES. LIGHT DUTY TRUCKS - DOMESTIC VS. FOREIGN PICKUP

van. The weight advantage of unit body-frame construction has long been known and this concept for future domestic pickups should be pursued. However, this is considered beyond the scope of this project. A major objection by U.S. manufacturers and users to the unitized construction for the pickup is the utilization of the same cab and chassis for mounting other more specialized bodies. Unit construction is considered less flexible for this application even though the current wide use of Dodge van unitized front end and chassis for small motor homes and box type van bodies appears to minimize the objection.

The Citreon-Fiat is also a front wheel drive design which has also been looked upon with disfavor by U.S. manufacturers and users because of a potential loss of traction resulting from a high percentage of the added cargo load being applied to the rear wheels. In a conventional layout, some of the cargo load can actually remove weight from the front wheels. Use of a long wheelbase relative to body length (low rear overhang) as used by Citreon-Fiat minimized this effect.

2.5.4.5 Load and Volume - Domestic Vans - A comparison of Load and Volume Efficiencies for vans is shown in Figure 2-18. The basic lowest GVWR models of each manufacturer plus models of Chevrolet and Dodge (crosshatched) with GVWRs comparable to Ford are compared. As discussed (Paragraph 2.5.1), on comparable GVWR basis, Dodge is the most efficient due, in part, to its use of unitized construction vs. Ford's separate frame and body. Ford also uses an engine position further forward in relation the the driver which adds to vehicle length. The advantage of Dodge, as compared to Chevrolet, which also uses unit construction, is apparently the result of individual wieght differences in many components, as was the case with the pickup. As mentioned previously, there are also minor differences in Curb Weight/GVWR but these are not considered significant. Table 2-9 summarizes the actual Weight, Load and Volume differences and Table 2-10 provides a dimensional comparison.

AMC and International do not offer models of this type, nor are there imported models except for the obsolete rear engine Volkswagen. The newer Volkswagen will be compared rather than the import.

2.5.4.6 Load and Volume - Domestic Vans vs. Foreign Vans - A comparison of Load and Volume Efficiencies of the most efficient U.S. make with representative foreign models is shown in Figure 2-19. Two Dodge models are used for the comparison because of different characteristics of the Curb Weight/GVWR ratio between the foreign

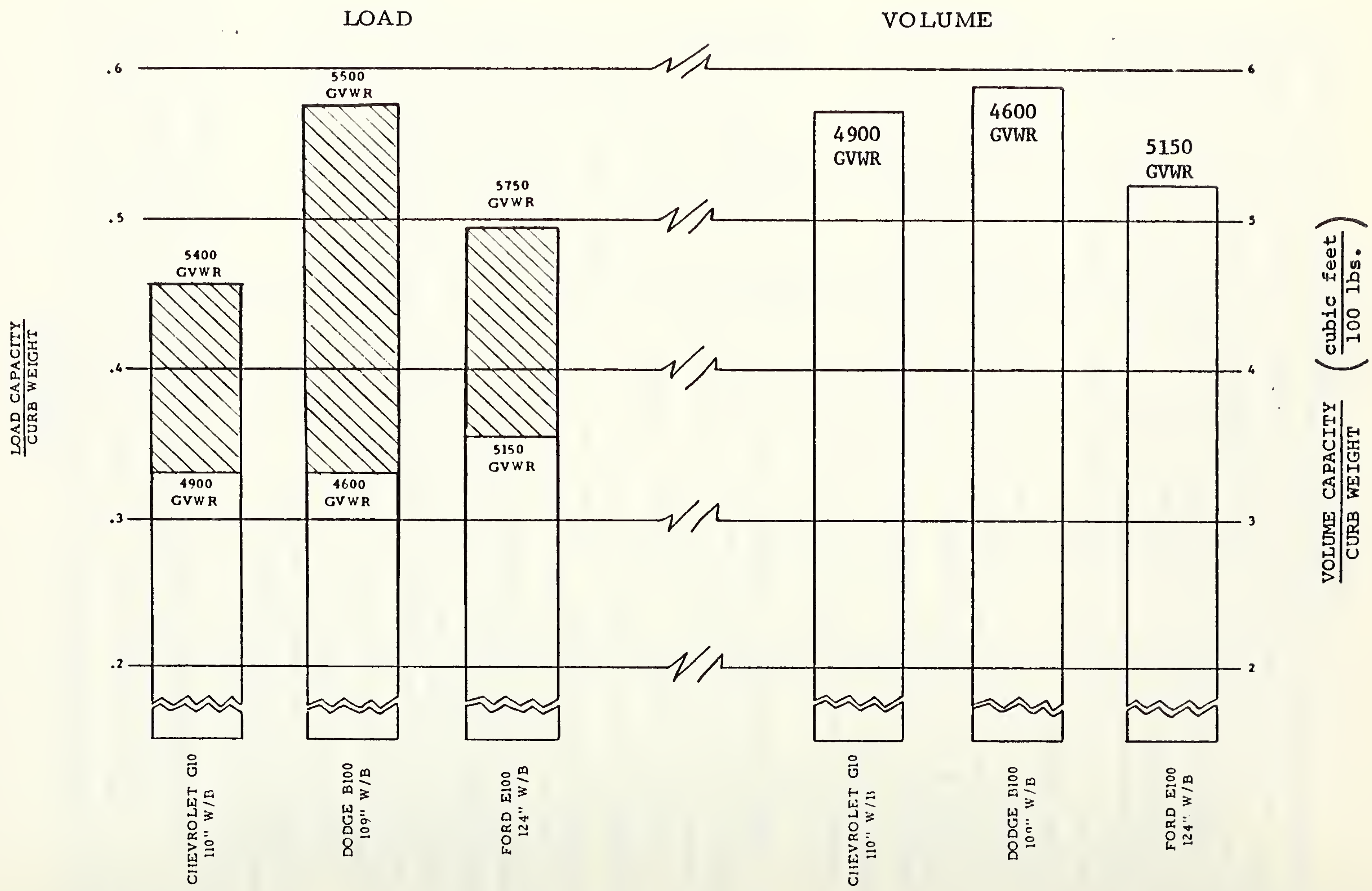


FIGURE 2-18 LOAD AND VOLUME EFFICIENCIES. LIGHT DUTY TRUCKS - VAN

TABLE 2-9 CURB WEIGHT, LOAD AND VOLUME CAPACITY COMPARISON,

VAN

	CHEVROLET G-10 110" W/B	DODGE B-100 109" W/B	FORD E-100 124" W/B
Curb Weight (Lbs.)	3666	3440	3795
Load Capacity (Lbs.)	1234	1160	1355
Volume Capacity ($Ft.^3$)	207.8	201.5	206.5

TABLE 2-10 DIMENSIONAL COMPARISON,

VAN

	CHEVROLET G-10 110" W/B	DODGE B-100 109" W/B	FORD E-100 124" W/B
Wheelbase (In.)	110.0	109.0	124.0
Overall Length (In.)	178.2	176.0	186.8
Width (In.)	79.5	79.8	79.8
Height (In.)	78.8	77.2	79.6
Cargo Area			
Length (In.)	94.2	92.9	93.0
Width (In.)	71.0	70.2	70.3
Height (In.)	53.7	53.2	54.0
Between Wheels (In.)	53.5	50.0	52.3

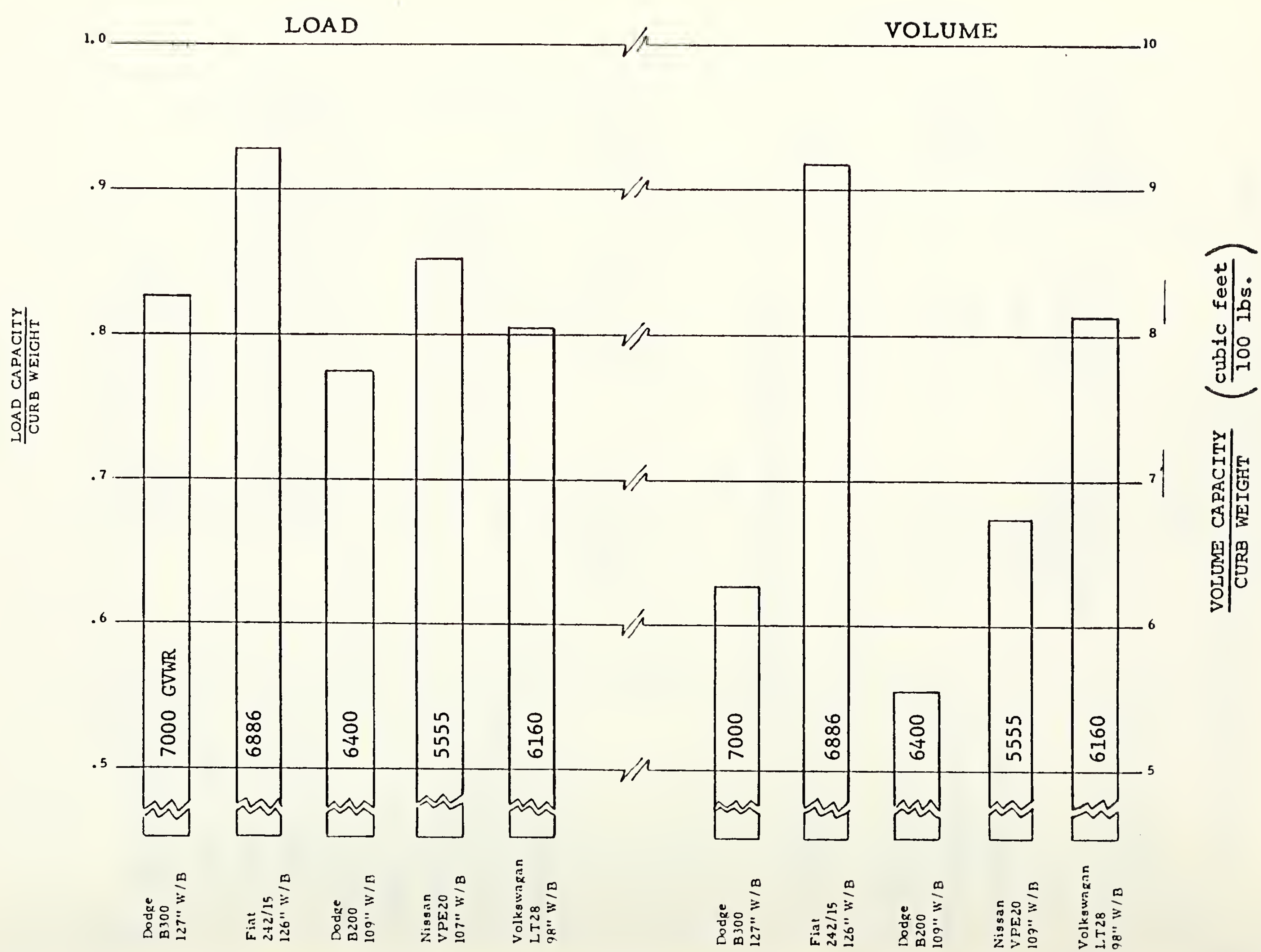


FIGURE 2-19 LOAD AND VOLUME EFFICIENCIES. LIGHT DUTY TRUCKS - VAN (DOMESTIC VS. FOREIGN)

models. Table 2-11 compares the actual Weight, Load and Volume Capacities and Table 2-12 the relative dimensions for the selected Dodge model and the Fiat. Table 2-13 and 2-14 provide similar comparisons between Dodge and the other Foreign van models.

The Load Efficiency of the Fiat is still better than Dodge but not by as wide a margin as observed for the pickup because the vehicle designs are more similar in construction - both unitized construction and forward control. This appears to verify the previous observation that a U.S. pickup based on a unitized forward control van would be more efficient than the current separate frame and body construction. Load Efficiencies of the other foreign vans are similar to the U.S. model. Volume Efficiencies of the foreign models, particularly the Fiat and Volkswagen are superior to the U.S. model. The Fiat is particularly good in part because of its exceptionally high height compared to the U.S. model. The Volkswagen is also significantly higher and has a much longer cargo length due to the far-forward seating position, which, because of frontal impact safety considerations, is not satisfactory for U.S. models.

Fundamental differences in design as well as lower performance levels for the foreign models make a direct comparison somewhat questionable. However, the comparisons are of interest in evaluating the relative results of different design philosophies.

2.5.4.7 Load and Volume - Utility Vehicles - Because of the limited number of Utility models offered, a separate comparison chart was not considered necessary. Reference to Figure 2-8 indicates the relationship of Load Efficiencies. The International Scout design is the most efficient. It is also somewhat smaller, as reflected by the reduced Volume Efficiency. Chevrolet and Dodge are equal in Load Efficiency with Dodge somewhat better in Volume Efficiency. Ford is significantly lower in both categories, and the AMC models cannot be compared directly because they are basically a different design concept. The AMC Jeep grew out of a small military vehicle whereas the big 3 models are based on pickup models. The unique design of the International is probably a significant factor in its higher Load Efficiency. Another factor in the International's higher load efficiency is its use of a 4-cylinder engine as standard equipment. It has a lighter weight but reduced performance. The lower ratio of Curb Weight/GVWR (.6 for International vs. .7 for Dodge) also indicates that the International design is not directly comparable to Dodge, as was discussed in the relationship of imported compact pickups to full size domestic models.

The only foreign model for which suitable information is available is the Nissan G60. It is similar to the International in size and Curb Weight but more similar to

TABLE 2-11 CURB WEIGHT, LOAD AND VOLUME CAPACITY COMPARISON,

U.S. vs EUROPEAN VAN

	DODGE B-300	FIAT 242/15
Curb Weight (Lbs.)	3835	3586
Load Capacity (Lbs.)	3165	3300
Volume Capacity (Ft.^{3})	240.5	328.4

TABLE 2-12 DIMENSIONAL COMPARISON,

U.S. vs EUROPEAN VAN

	DODGE B-300	FIAT 242/15
Wheelbase (In.)	127.0	126.0
Overall Length (In.)	194.0	195.3
Width (In.)	79.8	78.3
Height (In.)	78.7	92.8
Cargo Area		
Length (In.)	100.9	118.3
Width (In.)	70.2	70.5
Height (In.)	53.2	71.9
Between Wheels (In.)	50.0	51.2

TABLE 2-13 CURB WEIGHT, LOAD AND VOLUME CAPACITY COMPARISON,

U.S. vs FOREIGN VANS (FAR FORWARD CONTROL)

	DODGE B-200	NISSAN VPE 20	VOLKSWAGEN LT 28
Curb Weight (Lbs.)	3615	2990	3410
Load Capacity (Lbs.)	2785	2565	2750
Volume Capacity ($Ft.^3$)	201.5	200.4	277.0

TABLE 2-14 DIMENSIONAL COMPARISON,

U.S. vs FOREIGN VANS (FAR FORWARD CONTROL)

	DODGE B-200	NISSAN VPE 20	VOLKSWAGEN LT 28
Wheelbase (In.)	109.0	107.5	98.4
Overall Length (In.)	176.0	184.6	190.6
Width (In.)	79.8	66.5	79.5
Height (In.)	78.0	75.0	84.6
Cargo Area			
Length (In.)	92.9	112.3	121.6
Width (In.)	70.2	59.7	71.3
Height (In.)	53.2	51.8	57.5
Between Wheels (In.)	50.0	N.A.	54.0

the AMC Jeep in concept. It is superior to the Jeep in Load and Volume Efficiencies but not as good as the International in either.

Although the International has the highest Load Efficiency rating it is not used for the weight reduction study because:

- Its size does not provide comparable Volume Capacity to the big 3 models.
- Its 4-cylinder engine does not provide comparable performance.
- Its small percentage of the market does not warrant a separate study. (The Dodge has a high level of interchangeability of components with the Pickup.)

2.5.4.8 Passenger - There are no significant differences in Passenger Efficiencies for the domestic pickup models - all provide commodious accommodations for 3 passengers. Therefore, specific values were not calculated. A similar condition exists for the commercial model van.

Passenger Efficiencies for the Van-Wagon type vehicles were shown in Figure 2-11. Dodge exhibits the highest efficiencies with the "Maxi-Van" concept (a body extension without increase in wheelbase), which provides a significantly higher efficiency because of space for an additional three passengers.

No specific comparison with foreign vehicles is provided but the Citreon-Fiat again demonstrates a more efficient design. (Data in Appendix B). The Nissan is comparable to U.S. models. No data was provided by the manufacturer for a Van-Wagon version of the European Volkswagen model.

Passenger Efficiencies are not of great importance for the Utility models. Figure 2-12 provided a summary. The International has the highest Efficiency for reasons basically the same for Load Efficiency. The AMC Jeep again is not directly comparable. Nissan is the only foreign model for which sufficient information is available. It compares favorably (slightly better) with the International because of its Jeep-like concept, but unlike the Jeep it is extended for additional passenger capacity.

3. IDENTIFICATION OF MOST WEIGHT EFFICIENT DESIGN

3.1 SELECTION OF MAKES

A review of the Attribute Sheets, Appendix B, and more specifically the Attribute Comparisons of Section 2.5, shows that the lightest and most weight efficient design for each of the selected vehicle types is:

Pickup - Dodge

Van - Dodge

Utility - International

Since the Utility employs a high percentage of components from the Pickup (Chevrolet-Dodge-Ford), the major weight reduction effort will be directed toward the Pickup and Van. Dodge models are used for the "current" weight to which are applied the various weight reduction processes.

In spite of the more efficient design of the International, the Dodge Utility vehicle will be used for the weight reduction studies because of the high degree of component interchangeability with the Pickup and because of the availability of more specific weight data for the Dodge. The Curb Weight/GVWR ratio of the International (0.6) suggests that is is not directly comparable to the Dodge (0.7). This ratio is an indication of where the vehicle stands in a family of GVWRs based on one basic design. (See discussion of compact vs. full size Pickup, Section 2.5.4.2.)

3.2 COMPONENT WEIGHT DETERMINATION

To improve the accuracy of the weight reduction effort it was considered desirable to use actual vehicle component weights as a base. Accordingly, a Dodge Pickup and Van were obtained, disassembled, and actual component weights were measured. Disassembly proceeded to the level of components pertinent to the weight reduction process. Soft trim and electrical components were not included. The actual vehicles selected were:

a. Dodge D-100 Pickup

5000 GVWR

131" Wheelbase

Curb Weight Specified: 3580 lbs.

Curb Weight Actual: 3666 lbs.

6-Cylinder 225CID Engine

3-Speed Manual Transmission

Standard (base price) Equipment

b. Dodge B-100 Van

4600 GVWR

109" Wheelbase

Curb Weight Specified: 3400 lbs.

Curb Weight Actual: 3450 lbs.

V-8 318CID Engine

Automatic Transmission

Standard (base price) Equipment (except for V-8 engine and automatic transmission - not included in above actual weight).

Comments on the selected vehicle are:

1. The lowest GVWR vehicle was selected in each case because it is most representative of the basic design. Heavier models are obtained by changing individual load dependent component.

2. The 131-inch wheelbase Pickup was selected rather than the 115-inch wheelbase because it is a much higher volume version and therefore more representative of a typical Pickup. The 131-inch wheelbase is also the only one available on the higher GVWR models so for comparison purposes it is more desirable.

3. The V-8 engine and automatic transmission were selected for the Van because power plants are the same for both types and this selection gave the weight of the optional power plant as well as the standard equipment one. Adjustments were made to the Van weight to reflect a 6-cylinder and Manual Transmission.

4. A step-type rear bumper (not standard equipment) was not ordered but came with the Pickup. Its weight was deducted from the "Actual" Weight.

5. The difference between actual weight and specified curb weight for the Pickup is well within generally recognized production tolerance. The Chevrolet Data Book states "Model Weight may vary as much as + 150 pounds to allow for production build variation.")

A summary of the component weights is presented in Table 3-1. It is recognized that the lowest total weight does not necessarily mean that each component on the vehicle is also the lightest. All components selected for further weight reduction studies were visually compared with similar components of the other makes to insure use of the most weight efficient design for each. Where a significant weight difference was noted, manufacturer's data or actual parts were used to establish the lightest component. For example, a Chevrolet 6-cylinder engine was weighed and found to be lighter than the Dodge. It was therefore used for the base for both Pickup and Van. In general, manufacturer's data was not used because the weight groupings lacked sufficient qualifications in the form available to insure comparable values.

For most components, there appeared to be no significant weight difference between makes. This was anticipated because the vehicles are the same size (see Table 2-2), and the total curb weight differential is only slightly more than the production tolerance range.

Table 3-1 includes comments on the apparent reasons for weight differences when the difference was considered to be significant. The only component where Dodge was not the lightest was the engine. The Chevrolet engine was found to be 8 pounds lighter. Other differences of note:

1. Dodge Van is significantly lighter than Ford due to use of unitized versus separate body frame construction.

2. Engine weight differences are minor and are the result of internal design differences.

3. The Dodge front suspension design is significantly lighter than Chevrolet's. The design differences are in the lower control arm

TABLE 3-1 LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION,

MOST WEIGHT EFFICIENT DESIGN (1 of 5)

COMPONENTS	PICKUP (LBS)	VAN (LBS)	COMMENTS
Curb Weight	3572	3432	
Cab (w/o doors, glass, hardware and trim)	258.5	-	No significant weight difference between makes.
Body (w/o doors, glass, hardware and trim)	-	972.5	Dodge unitized construction considerably lighter than Ford separate body and frame. Dodge 2" shorter than Chevrolet.
Cab Door (w/o glass, hardware and trim) (2)	80.0	78.0	No significant weight difference between makes.
Cab Door Glass (2)	16.0	14.0	" " " " " "
Cab Door Glass Regulator (2)	8.0	8.0	" " " " " "
Cab Door Vent Glass Assembly (2)	10.0	10.0	" " " " " "
Cab Rear Window	13.5	-	" " " " " "
Windshield	31.0	43.5	" " " " " "
Cargo Doors			
Side (2)	-	57.0	" " " " " "
Rear (2)	-	50.0	" " " " " "
Instrument Panel Assembly	28.0	24.0	" " " " " "
Heater Assembly	16.0	19.8	" " " " " "
Seat Assembly			
Single	-	25.0	" " " " " "
Platform		15.3	" " " " " "
3 Passenger Bench	73.0		

TABLE 3-1 LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION,

MOST WEIGHT EFFICIENT DESIGN (2 of 5)

COMPONENTS	PICKUP (LBS)	VAN (LBS)	COMMENTS
Hood	55.0	17.5	No significant weight difference between makes.
Hood Hinge Bracket (2)	10.0	-	" " " " " "
Cowl Vent Panel	4.0	4.0	" " " " " "
Front Fender (2)	52.0	-	Dodge integral inner panel lighter.
Front Fender Inner Wheelhouse (2)	21.0	-	No significant weight difference between makes.
Front Fender Battery Tray	3.0	-	" " " " " "
Grille Assembly	5.8	9.0	" " " " " "
Grille Lower Panel	4.0	-	" " " " " "
Front Structure			
Radiator Support	-	7.5	Ford heavier because of separate frame construction.
Radiator & Front Fender Support	40.0	-	No significant weight difference between makes.
Cargo Box	384.0	-	" " " " " "
Power Plant Assembly - Complete	674.5	674.5	
Engine Assembly - Complete	586.0	586.0	Chevrolet engine slightly lighter than Dodge. Ford engine is heavier.
Transmission Assembly - Complete	88.5	88.5	No significant weight difference between makes.
Radiator	14.0	14.0	" " " " " "
Prop Shaft	24.0	12.5	" " " " " "
Rear Axle Assembly (w/o brakes)	188.8	159.5	" " " " " "

TABLE 3-1 LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION

MOST WEIGHT EFFICIENT DESIGN (3 of 5)

COMPONENTS	PICKUP (LBS)	VAN (LBS)	COMMENTS
Frame (not incl. eng. rear support C/M	350.0	-	No significant weight difference between makes.
Engine Rear Support Crossmember	20.5	5.5	" " " " " "
Engine Mounting Brackets (3)	8.5	8.5	One engine mounting bracket heavier in Dodge because of slant engine.
Front Suspension Crossmember	-	36.0	No significant weight difference between makes.
Front Susp. Upper Control Arm Assy. (2)	14.5	14.5	Dodge arm several pounds lighter then Chevrolet.
Front Susp. Lower Control Arm Assy. (2)	18.0	18.0	Dodge several pounds lighter than Chevrolet because of the strut type of construction of the lower arm. Also much lighter than Ford twin I-Beam construction.
Front Susp. Lower Control Arm Strut (2)	10.5	13.0	" " " " " "
Front Suspension Spring (2)	24.0	23.0	No significant weight difference between makes.
Front Susp. Shock Absorber (2)	4.5	4.5	" " " " " "
Rear Suspension Spring (2)	69.0	57.6	" " " " " "
Rear Susp. Spring Shackle Assy. (2)	3.0	9.0	" " " " " "
Rear Susp. U-bolt Plate (2)	10.0	5.0	" " " " " "
Rear Susp. Shock Absorber (2)	7.0	8.5	" " " " " "
Steering Gear	15.5	13.5	" " " " " "

TABLE 3-1 LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION,

MOST WEIGHT EFFICIENT DESIGN (4 of 5)

COMPONENTS	PICKUP (LBS)	VAN (LBS)	COMMENTS
Steering Gear Arm	2.5	2.5	No significant weight difference between makes.
Steering Knuckle and Arm (2)	31.0	31.0	Dodge knuckle design lighter.
Steering Linkage Assembly	19.0	36.2	No significant weight difference between makes.
Steering Column and Wheel	24.5	21.2	" " " " " "
Wheel Brake - Front (Disc) (2)	36.5	36.5	" " " " " "
Wheel Brake - Front Rotor (2)	55.5	55.5	" " " " " "
Wheel Brake - Rear (Drum) (2)	22.0	22.0	" " " " " "
Wheel Brake - Rear Drum (2)	26.0	26.0	" " " " " "
Brake Master Cylinder Assembly	10.2	10.2	" " " " " "
Brake Pedal and Shaft	4.0	4.0	" " " " " "
Parking Brake Pedal, Brkt. & Frt. Cable	4.0	4.5	" " " " " "
Road Wheel (5)	107.5	107.5	" " " " " "
Tire (5)	130.0	107.5	Ford uses smaller tire as standard on pickup because of lower GVWR. Dodge smaller on Van because of lower GVWR.
Exhaust System	37.5	45.0	No significant weight difference between makes.

TABLE 3-1 LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION,

MOST WEIGHT EFFICIENT DESIGN, (5 of 5)

COMPONENTS	PICKUP (LBS)	VAN (LBS)	COMMENTS
Fuel Tank	21.0	22.2	No significant weight difference between makes.
Front Bumper			
Face Bar	29.0	28.0	" " " " " "
Mounting Bracket (2)	4.0	6.5	" " " " " "
Rear Bumper			
Face Bar	61.5*	23.0	" " " " " "
Mounting Bracket (2)	-	5.0	" " " " " "

*STEP TYPE (NOT STANDARD EQUIPMENT)

construction and in the knuckle. The Ford Twin-I-Beam construction is heavier than the Chevrolet suspension design.

Differences in weight between the Dodge Pickup and Van are mainly the result of the obvious difference in body configuration (reference Figure 2-2 and 2-3). The Pickup Prop Shaft is heavier because of added length (131-inch versus 109-inch wheelbase), which also requires a large diameter for critical speed control. Rear axle size and weight are the result of a higher GAWR (Gross Axle Weight Rating) for the Pickup due to a different weight distribution (including cargo load). This places a higher percentage of total vehicle load on the rear axle of the Pickup. Rear springs are heavier in the Pickup for the same reason.

The rear suspension shackle on the Van is heavier because it includes a mounting bracket which is part of the frame assembly on the Pickup. The rear suspension U-bolt plate is heavier on the Pickup because it includes the lower mount for the shock absorber which is welded to the axle on the Van.

The steering linkage is heavier for the Van because of an extra linkage required due to the forward control driver's position. Exhaust system weight differences are primarily the result of the larger components required with a V-8 opposed to a 6-cylinder engine. This difference was compensated for in the power plant weight adjustment. The rear bumper is heavier on the Pickup because it includes a step for entering the cargo area while the Van has a conventional design. (A rear bumper is not included as standard equipment on the Pickup and is not included in the weight used for analysis.)

4. POTENTIAL FOR REDUCTIONS IN FUNCTION

4.1 IDENTIFICATION OF FUNCTIONS

The process of developing and evolving light duty vehicles has in recent years resulted in a trend to larger, heavier and higher performance vehicles. Several functional characteristics were investigated to determine whether reductions in function were feasible for the purpose of achieving significant fuel economy improvement without impairing the ability of the vehicle to perform its missions as currently defined. The functions considered were:

a. Load Capacity,
b. Volume Capacity,
c. Passenger Capacity, and
d. Performance.

4.2 LOAD CAPACITY

The current Load Capacity of the minimum GVWR light duty vehicle ranges from 1040 to 1535 pounds (Appendix B). Since the minimum concept of a light duty truck has traditionally been a "1/2 ton" cargo capacity, a minimum of 1000 pounds appears to be basic. A value less than 1000 pounds would not be suitable for most commercial missions.

The original 1000 pound capacity was based on a two-passenger cab and none of the current range of extra equipment and accessories. By current practice, passenger weight and the weight of all optional equipment is deducted from cargo (load) capacity (GVWR is constant). Adding provisions for the more basic of the optional equipment items and the extra passenger yields:

1000 lbs.	Base
150	Added Passenger (3 vs. 2)
108*	Optional V-8 (minimum size)
26*	Automatic Transmission
13*	Power Brake
29*	Power Steering

*From Chevrolet Data Book.

50*	Rear Bumper
93*	Air Conditioning
6*	Radio
1475 lbs.	

It appears that the current load range is no more than adequate for present conditions on the basis of the above analysis. While potentially lighter vehicles may reduce the need for power steering and brakes and some reduction of accessory weights can be anticipated, these changes will not have a significant effect. It is concluded, therefore, that all weight reduction efforts will be directed toward Curb Weight and Load Capacities will be held constant.

4.3 VOLUME CAPACITY

This size factor applies to the space devoted to cargo. Cargo area rather than volume is significant in a Pickup since volume is traditionally calculated on the basis of the height of the integral sides of the cargo box. Obviously, without a roof, much greater volumes can be carried.

The size of the present cargo box has been established by the ability to lay a 4' X 8' piece of building material flat on the floor. (A shorter 6½' box length is offered by all manufacturers, but it seems to be used primarily for personal transportation, not commercial use.) While this determination may appear arbitrary, practice has indicated that it provides a suitable size for multiples of many types of cargo of smaller individual size. Therefore, the general acceptance of this "standard" has prompted a decision to maintain it for the reduced weight proposal. However, within the confines of a 4' X 8' floor area, it is possible to reduce cargo box size as follows:

-2" between wheelhouses (all currently 50" or over).

-1" from each side outboard of the wheelhouses.

The weight saving attributed to the above size reduction will be included in the potential reduction for both the pickup and Utility (based on Pickup). Van width, on the other hand, cannot be reduced because of passenger space requirements in the wagon version.

*From Chevrolet Data Book.

4.4 PASSENGER CAPACITY

Current conventional full size Pickups provide a three-passenger cab capacity. It is proposed that the capacity be maintained for the reduced weight light duty vehicle. This recommendation is based on the following considerations:

1. The potential to require three-passenger space for transport of working personnel when the vehicle is in commercial use. Examples are: utilities and construction.
2. The downsized weight efficient full size passenger cars still provide six-passenger seating accommodations (3 in front).

However, the present cab size provides an opportunity to reduce width by four inches (same as cargo compartment) and still provide for three-passenger seating by current passenger car standards. The following dimensions justify this position:

Passenger Compartment Seat Width Comparison	
Current Pickup*	= 60"
Proposed Pickup	= 56"
'77 & '78 Full Size Passenger Car*	= 54"

*Chevrolet

The same width reduction will be applied to the Utility vehicle which has a large number of interchangeable parts.

Because of the frequent use of current vans for public or personnel transportation (mini-bus) and the growing necessity for mass transport, it is recommended that present van size and passenger capacity be continued. Passenger seat width is now a minimum for three passengers. (54")

4.5 PERFORMANCE

Vehicle performance can be expressed in many ways but the functional factors which are of interest to this study are those affected by the power available (or torque) in relation to GVW. Performance as a function of power is usually measured in terms of:

Acceleration
Gradeability
Top Speed

Because of the continued prospect for highway speed restriction (55 m.p.h.), top speed is not a factor of concern. Acceleration and highway grade ability are a function of the same relationship - Power Available vs. Power Required. Both performance factors are relatively easy to measure with proper equipment but difficult to calculate because of the many variables involved. However, the dominant factor in these calculations is the ratio of Horsepower to Gross Vehicle Weight. Variations in body size and shape, driveline ratios, chassis and tire friction losses and tire size will vary the performance for a given Horsepower/Weight ratio. For the purposes of this report, variations in the above factors will be minimal and therefore use of the Horsepower/Weight ratio as a basis for performance comparison should be as accurate as any other type of performance calculation.

In a report* on vehicle design analysis, the relationship of Horsepower/Weight to various "levels" of acceleration performance was established on the basis of published test results of various motoring magazines. While the values obtained appear to agree with general automotive experience, the changes in the factors of frontal area, drag coefficient, and chassis friction between cars and trucks appear to rule out use of the derived relationship for truck calculations. Futhermore, any reduced level of performance and its effect on buying habits and traffic flow would be highly speculative without actual test data. Therefore, it was decided to provide the proposed reduced weight level vehicles with the same level of performance as the minimum provided by a comparable 1978 model.

In addition to adequate power for certain types of performance, trucks must have torque to start the loaded vehicle on a grade. For example, this requirement is encountered when starting up on a depressed access to a loading dock. There are many other circumstances as well where this type of tractive force is required.

Another measure of adequate engine size for acceptable vehicle performance, as recommended by G.M.**, is engine swept combustion volume per ton mile at full load.

Vehicle performance levels, therefore, will be evaluated by the following formulas:

$$PF_A = \frac{H.\ P.}{GVWR}$$

where: PF_A = Performance Factor - Activity (a measure of potential Acceleration and Gradeability Performance)

*S.A.E. Report 760045 by Malliaris, Hsia, and Gould and Included in the report of the Automotive Design Analysis Panel of the Task Force on Motor Vehicle Goals Beyond 1980.

**Contained in Manufacturers reply to Proposed rule making for 1980-81 Non-Passenger Automobile Fuel Economy Standards U.S., D.O.T., N.H.T.S.A.

H.P. = Maximum Horsepower Rating

GVWR = Gross Vehicle Weight Rating (lbs.)

$$PF_T = K_T \frac{TR\ (N/V)^*}{GVWR}$$

where: PF_T = Vehicle Tractive Force. Minimum acceptable performance in formula = 1 which is equivalent to a 17 percent Gradeability for Starting under Full Load.

T = Maximum Engine Torque (foot-pounds)

R = Maximum Transmission Torque Multiplication Ratio (Includes Automatic Transmission Torque Converter Stall Ratio.)

K_T = Constant

= 0.230 for Manual Transmission

= 0.155 for Automatic Transmission

$N/V = \frac{RY}{60}$ or $\frac{\text{Engine RPM}}{\text{Vehicle Speed (M.P.H.)}}$

where: R = Rear Axle Ratio

Y = Tire Revolutions Per Mile (from Tire Data Books)

GVWR = Gross Vehicle Weight Rating (lbs.)

$$PF_S = \frac{0.6\ (CID)\ (N/V)}{GVWR}$$

where: PF_S = Engine Swept Combustion Volume per Ton Mile. Minimum acceptable value in formula = 1 which is equivalent to 58 cubic feet per Mile per Ton in High gear at maximum GVWR.

CID = Engine Displacement (cubic inches)

$N/V = \frac{RY}{60}$ or $\frac{\text{Engine RPM}}{\text{Vehicle Speed (M.P.H.)}}$

where: R = Rear Axle Ratio

Y = Tire Revolutions Per Mile

GVWR = Gross Vehicle Weight Rating (lbs.)

The data necessary to define the previously slected performance parameters for current production vehicles was obtained from Manufacturer's Data Books. The data are tabulated in Appendix C.

*Developed by Transportation Systems Center, D.O.T. from Industry recommendations for minimum performance levels.

The current range of PF_A (Performance Factor - Activity) for light duty vehicles is displayed graphically in Appendix D. Minimum performance level of the big three makes is shown in Figure 4-1. Based on this data, the performance levels for the minimum GVWR models for each manufacturer are:

PF_A - MINIMUM GVWR MODELS

	PICKUP	VAN
Chevrolet	0.023	0.023
Dodge	0.023	0.025
Ford	0.025	0.024

The PF_A that must be maintained for the reduced weight models will, therefore, be 0.023. Acceleration time from the previously referenced relationship would be approximately 18 sec. for 0-60 MPH. For the differences previously mentioned, the actual time for a truck would probably be higher.

For reference, PF_A values for the Foreign models selected for Load and Volume comparisons, are listed below:

PF_A - Selected Foreign Models

	VAN
Citreon-Fiat	0.009**
Nissan	0.0165
Volkswagen	0.012

Also of interest is the 4-cylinder International, PF_A = 0.014, and the imported Pickup at 0.020.

The PF_A factors for the low horsepower models are too far off the established curve for it to be aplied, but it is estimated that the 0.009 ratio would result in acceleration time for 0-60 MPH of over 30 sec.

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*SAE 760045

**The comparable Dodge model used for Load and Volume comparisons has a PF_A of 0.017 with the 6-cylinder engine.

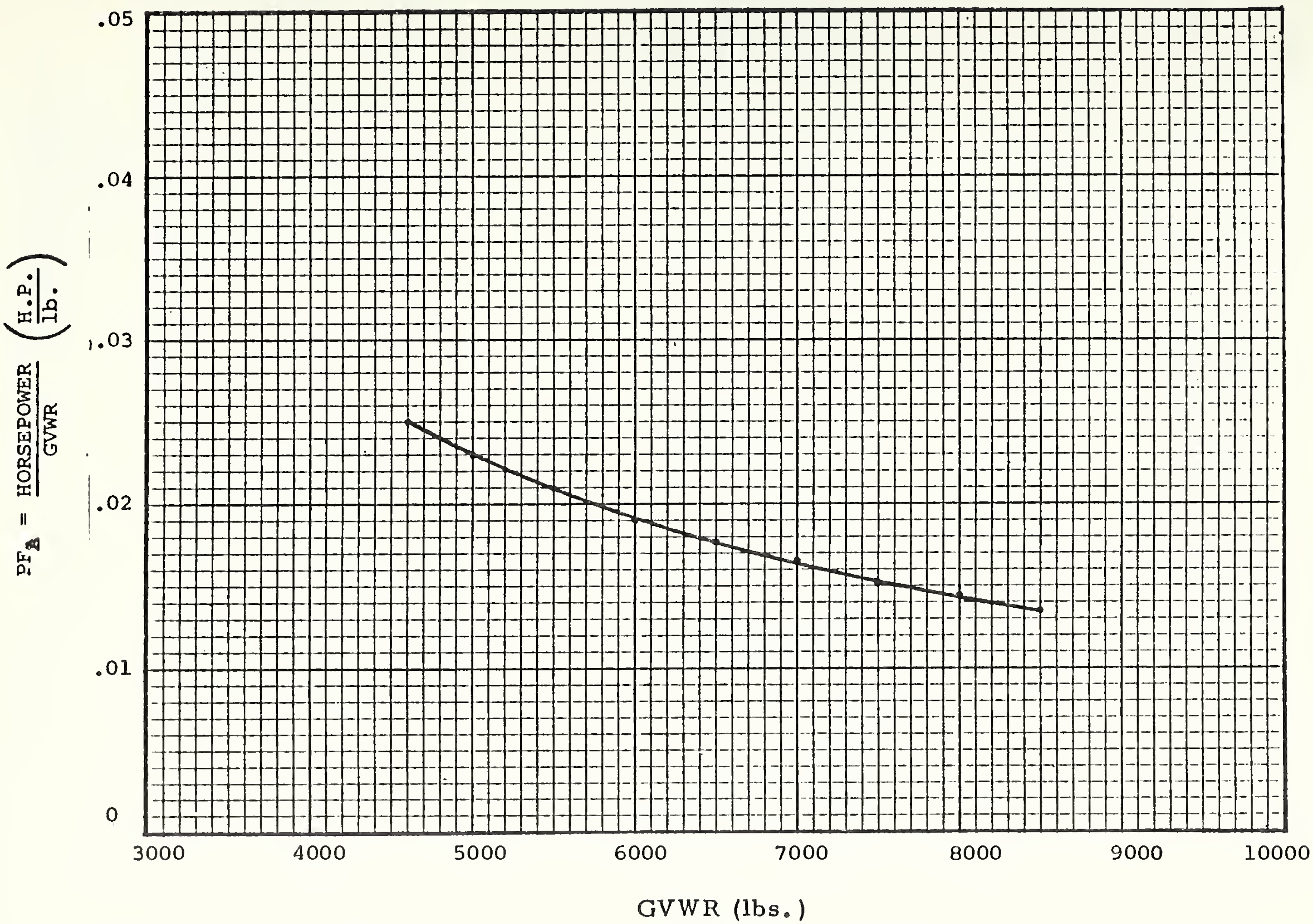

FIGURE 4-1 PERFORMANCE POTENTIAL CURRENT MINIMUM - LIGHT DUTY TRUCKS
CHEVROLET - DODGE - FORD

5. WEIGHT REDUCTION POTENTIAL

5.1 DESIGN CRITERIA

Guidelines for determining the weight reduction potential of light duty trucks is based on the previously established ground rules (Section 4.). Significant functions will be retained at current levels (except as noted).

1. Load Capacity
2. Volume Capacity

    Four inch width reduction for Pickup and Utility -

    48 inches maintained between rear wheel housings.

    Two inch height reduction in Utility.
3. Passenger Capacity
4. Performance

Weight reduction efforts were initiated at the minimum component weight level of current production models. Minimum levels were indicated in Table 3-1. Actual weights were obtained by disassembling the vehicle containing the lowest, or typical weight components. In some instances, estimates were made of portions of components which could not be disassembled without destroying the assembly. The roof panel of the Pickup cab is an example.

Vehicle types selected for analysis are:

Pickup
Van
Utility

Analysis is directed to the base model (lowest GVWR) with standard equipment as specified in the base price of the vehicle.

The basic approach involves the establishment of a technically feasible maximum weight reduction potential. Restrictions of piece cost and current manufacturing technology are not considered as limitations to the potential, although the effects of these aspects will be discussed in Section 6.

The weight reduction study is divided into the following stages:

a. Product Dependent Weight

    Size Reduction

    Redesign

    Material Substitution

b. Power Dependent Weight

Powerplant and Driveline reduction based on Product Dependent Weight Reduction

c. Weight Dependent Weight

Propagation effects on components in this category. Size, design and material substitution effects on certain weight dependent components (Frame, wheels, etc.,) have been included in the Product Dependent Weight analysis for convenience.

The potential for weight reduction has been established within the criterion of maintaining the function and durability of all components at current levels. It was necessary, therefore, to establish the design criteria for the components involved. Table 5-1 lists the criteria established for the components involved in the weight reduction study. Only those criteria considered relevant to the weight reduction effort are included. The primary or most critical criteria are listed first.

Individual detail summaries are provided for each stage of the process for each type of vehicle. These sheets include a referenced illustration where is was considered helpful and the basic manufacturing process for each component where applicable. Summary sheets for each portion of the work for each type of vehicle are also provided.

5.2 SIZE REDUCTION

The efforts of General Motors to achieve significant weight reduction by "downsizing" its full and intermediate size passenger cars have been widely publicized. Similar results for light duty trucks cannot be achieved without material substitution. The difference between actual size and functional size which existed on U. S. full size cars (prior to 1977 for G. M.) does not exist to the same degree on trucks. Therefore, a similar magnitude of weight reduction by "downsizing" does not exist for trucks. This project does not attempt to evaluate how much of the light truck functional market could be effectively served by a smaller (compact) size vehicle. A shift of some additional portion of the fleet appears inevitable.

The weight saving potential for the specified size reductions which are considered feasible without impairing function are shown in Table 5-2 for the Pickup and Table 5-7 for the Utility.

As noted previously, a size reduction for the van is not considered functionally feasible because of the passenger-carrying function of the Van-Wagon.

TABLE 5-1 DESIGN CRITERIA - LIGHT DUTY TRUCKS (1 OF 2)

COMPONENT	CRITERIA
STRUCTURAL COMPONENTS	
BODY (CAB) ROOF-OUTER REAR PANEL SIDE PANELS FRONT QUARTERS-OUTER DOOR-OUTER COWL PANEL-OUTER HOOD-OUTER GRILL LOWER PANEL FRONT FENDER-OUTER CARGO BOX FLOOR* FRONT PANEL SIDE PANELS-INNER AND OUTER TAILGATE*	STIFFNESS FABRICATION & HANDLING DENT RESISTANCE
BODY ROOF-INNER DASH PANEL FLOOR DOOR-INNER HOOD-INNER FRONT FENDER-INNER RADIATOR SUPPORT BATTERY TRAY	STIFFNESS STRENGTH FABRICATION & HANDLING
WHEELHOUSE	IMPACT RESISTANCE STIFFNESS

*DENT (IMPACT) RESISTANCE VERY IMPORTANT

TABLE 5-1 DESIGN CRITERIA - LIGHT DUTY TRUCKS (2 OF 2)

COMPONENT	CRITERIA
STRUCTURAL COMPONENTS (Continued)	
BODY	
COWL SIDE	
SILL	
ROOF BOWS	
SIDE CHANNELS	
HOOD HINGE BRACKET	
CARGO BOX	
FLOOR SUPPORT CHANNELS	
FRAME	STRENGTH
ENGINE MOUNTING BRACKETS	STIFFNESS
FRONT SUSPENSION CROSSMEMBER	
FRONT SUSPENSION CONTROL ARMS	
REAR SUSPENSION SPRING SHACKLE	
REAR SUSPENSION ASLE U-BOLT PLATE	
BRAKE & CLUTCH PEDALS	
PARKING BRAKE PEDAL & BRACKET	
FUEL TANK	
BUMPER MOUNTING BRACKET	
SEAT PLATFORM (VAN)	
RADIATOR SUPPORT BRACKETS (VAN)	
POWERTRAIN COMPONENTS	
ENGINE	HORSEPOWER TORQUE EFFICIENCY
TRANSMISSION	TORQUE CAPACITY TORQUE RATIOS
REAR AXLE	STRUCTURAL STRENGTH TORQUE CAPACITY TORQUE RATIOS

Use of a compact size Van for a portion of the fleet is a possibility which will not be dealt with in this study.

5.3 REDESIGN

The basis for redesign is that material can be used more efficiently if minimum weight is recognized as a major goal in component design. This approach generally requires a completely new vehicle design in order to gain maximum results and to insure compatibility of redesigned components. Use of modern design aids such as finite element analysis enable a more precise determination of structural requirements. This approach has been utilized in recent passenger car redesigns in conjunction with the "downsizing" process.

While "downsizing" does not have the same potential for trucks as it does for cars, the more efficient use of material should be applicable. It is generally considered that truck design has been more conservative than passenger car design, largely because of the more extreme duty cycle to which many trucks are subjected. Ford, for example, has stated that their endurance test requirements are four times as severe for trucks as for cars.* While a comprehensive, detailed redesign program for all major components is beyond the scope of this study, certain assumptions can be made, based on current design experience, which will enable a reasonable assessment of the potential for weight reduction by a modern concept of vehicle design.

Examination of the design criteria, Table 5-1, indicates that most structural components are either stiffness or stiffness/strength critical. To maintain constant stiffness the product EI (Material Modulus - Section Moment of Inertia) must be maintained at a constant level. Without material change the only potential for weight reduction lies in change of the Section Moment of Inertia.

To achieve an absolute evaluation of the effects of redesign would require an individual analysis of the structural function of each component and its relation to the overall design. Such an analysis is beyond the scope of this project: it would involve a complete structure design for a new series of light duty vehicles. However, a reasonable estimate of the effects of redesign based on experience appears feasible.

The stiffness critical panels selected are assumed to conform to flat plate theory although some appear to deviate from the technical definition. Based on recent apparently successful experimental or production applications of substitute materials,

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*Contained in Manufacturers reply to Proposed Rule Making for 1980-81 Non-Passenger Automobile Fuel Economy Standards - U.S., D.O.T., N.H.T.S.A.

significant reductions in stiffness have been satisfactory. The proportion due to actual section stiffness reduction vs. maintaining stiffness by section modification, permitting use of thinner material, cannot be determined in this study. Using the flat plate stiffness formula, and adjusting stiffness levels, does give comparable results. This process will be used. On this basis, the following criteria are assumed:

- For major structural members such as cab roof, floor, etc., use 75 percent of the current stiffness. For lightly loaded non-critical structural numbers such as cab doors, hoods, etc. (commonly called hang-on parts), use 60 percent of the current stiffness.

A comparison of panel thickness reduction resulting from these criteria with "conservative" recommendations from ALCOA indicate close agreement.

THICKNESS COMPARISON
DOOR OUTER PANEL
ALUMINUM VS. STEEL

By 60 percent critical assumption:*

$$t_{AL} = t_{ST} \sqrt[3]{0.6 \frac{E_{ST}}{E_{AL}}} = t_{ST} \sqrt[3]{0.6 \text{ X } \frac{29 \text{ X } 10^6}{10 \text{ X } 10^6}} = 1.20\ t_{ST}$$

"Conservative" ALCOA recommendation = $t_{AL} = 1.19\ t_{ST}$**

It should be noted that the ALCOA recommendation is based on passenger car practice, which reduces the aluminum thickness to 0.037. The weight reductions in this report are based on traditionally heavier truck gauges which result in an aluminum thickness of 0.048 for this application. This seems more appropriate for truck applications. It is also important to note that some manufacturers may have reduced gauges on some parts of current models which would reduce the weight saving potential.

It is recognized that sophisticated design techniques or actual development testing could result in modifications to the weight reductions indicated but it is believed that the values represent a potentially achieveable goal. It is also recognized that weight savings of the magnitude represented by the above criteria can only be achieved in conjunction with a complete redesign of all associated components and that extensive durability testing would be required to justify the assumptions.

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*See Appendix E for formula development.

**ALCOA reply to N.H.T.S.A. Questionnaire, November 21, 1977.

Formulas used for the assumed criteria are: (See Appendix E for development)

At 75 percent Current Stiffness level*

$$W' = W \sqrt[3]{0.75} = 0.91\ W$$

At 60 percent Current Stiffness level*

$$W' = W \sqrt[3]{0.60} = 0.84\ W$$

Some of the redesign (and also later material substitution) is based on specific industry recommendations or new designs currently in process.

The detail weight reduction potential of Redesign based on the foregoing criteria and assumptions is tabulated in Tables 5-3, 5-5 and 5-8 for the Pickup, Van and Utility respectively. Weights used for the base (current) have been reduced by the results of size reduction. The indicated frame weight reduction for the Pickup and Utility is based on experiemental results of suppliers since the combination of stiffness and strength criteria for a frame structure was considered too complex for generalization. A similar reduction was applied to the underbody of the Van, which is essentially a frame structure welded into the body structure.

5.4 MATERIAL SUBSTITUTION

The same basic design criteria that were used for redesign are utilized to determine the weight reduction potential for Material Substitution. However, the results are not additive since the same formulas are used and, therefore, the specified stiffness reduction is included in the material substitution calculation. The stiffness criteria formulas used are: (See Appendix E for development).

At 75 percent Current Stiffness level* for Aluminum vs. Steel

$$W' = 0.46\ W$$

At 75 percent Current Stiffness level* for HMC (plastic) vs. Steel

$$W' = 0.50W$$

At 60 percent Current Stiffness level* for Aluminum vs. Steel

$$W' = 0.425W$$

*For parts functioning per "Flat Plate" classification.

The detail weight reduction potential by Material Substitution based on the foregoing criteria and assumptions is tabulated in Tables 5-4, 5-6 and 5-9 for the Pickup, Van and Utility, respectively.

Where impact resistance was the criterion, weight reduction was based on the minimum thickness of the substitute material that was judged acceptable for impact resistance.

In the application of HSLA steels, where strength and stiffness were jointly the criteria, a conservative weight savings of one-third the amount indicated by the relative yield strengths of the materials was used (-15 percent) because of the complexity of the relationship. This reduction agrees reasonably well with results obtained from application work by material and part suppliers.

5.5 SUMMARY - PRODUCT DEPENDENT WEIGHT REDUCTION

The results of the foregoing weight reduction studies for the Product Dependent Components are summarized in Table 5-10. Once again, it should be pointed out that the three phases are not additive since several parts are included under one heading, each with different methods of weight reduction (The cab door, for example, includes both door structure and glass, which have different elements of design and material weight reductions applied.). Furthermore, the same basic formulas are used for both phases; therefore, the stiffness reductions used as a basis for the redesign weight reductions are included in the material weight reduction calculations. Therefore, the results of the two approaches are not additive. A few Weight Dependent components (suspension arms, wheels, etc.) have been included for convenience.

The potential weight reductions from Table 5-10 applied to the current minimum weight models provide new curb and GVWRs as follows:

WEIGHT REDUCTION - PRODUCT DEPENDENT WEIGHT

	PICKUP	VAN	UTILITY
Current Minimum Curb Weight	3752	3432	4285
Weight Reduction	586	391	551
Potential Curb Weight	2986	3041	3734
Current GVWR	5000	4600	6100
Revised GVWR	4400	4200	5550

TABLE 5-2 (1 of 2)

LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION
POTENTIAL SAVING BY SIZE REDUCTION

TYPE Pickup

COMPONENTS	FIG.	PROCESS	WEIGHT (LBS.) CURRENT	PROPOSED	SAVING
4" WIDTH REDUCTION (2" BETWEEN WHEELHOUSES - 1" OUTBOARD EACH SIDE)					
Cab	5.1				
Roof		Stamping	52.0*	48.8	3.2
Rear Panel		Stamping	31.5*	30.0	1.5
Dash Panel		Stamping	32.0*	30.2	1.8
Floor		Stamping	44.0*	41.5	2.5
Windshield		Glass	31.0	28.7	2.3
Rear Window		Glass	13.5	12.3	1.2
Hood		Stamping	55.0	51.3	3.7
Radiator Support	5.3	Stamping	40.0	39.5	0.5
Grill Lower Panel	5.4	Stamping	4.0	3.7	0.3
Cargo Box	5.4				
Floor	5.6	Stamping	107.8*	101.8	6.0
Floor Support Channels (5)		Stamping	55.0*	52.0	3.0
Floor Panel		Stamping	22.0*	21.0	1.0
Tailgate		Stamping	44.0	42.0	2.0
Bumper - Front			29.0	27.3	1.7
Frame (-2" only)	5.7		350.0	345.0	5.0
Engine Rear Support Crossmember (-2" only)	5.7		20.5	19.7	0.8
Seat			73.0	68.0	5.0
Grill, Instrument Panel, Etc.			-	-	3.5

*Estimated

TABLE 5-2 (2 of 2)

LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION
POTENTIAL SAVING BY SIZE REDUCTION

TYPE Pickup

COMPONENTS	FIG.	PROCESS	WEIGHT (LBS.) CURRENT	PROPOSED	SAVING
2" HEIGHT REDUCTION (1" ABOVE BELT - 1" BELOW BELT)					
Cab	5.1				
Rear Panel		Stamping	30.0	28.7	1.3
Dash		Stamping	30.2	29.4	0.8
Cowl Side (2)		Stamping	22.0*	21.3	0.7
Door (2)		Stamping	80.0	78.1	1.9
Windshield		Glass	28.7	27.0	1.7
Door Glass (2)		Glass	16.0	15.1	0.9
Rear Window		Glass	12.3	11.3	1.0
Fender (2)	5.5	Stamping	52.0	50.1	1.9
6" LENGTH REDUCTION - FRONT END SHEET METAL					
Fender (2)	5.5	Stamping	50.1	45.0	5.1
Hood	5.3	Stamping	51.3	44.9	6.4
TOTAL					66.7

TABLE 5-3 (1 of 2)

LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION
POTENTIAL SAVING BY REDESIGN

TYPE PICKUP

COMPONENTS	FIG.	PROCESS	WEIGHT (LBS.) CURRENT Ø	PROPOSED	SAVING	CRITERIA
Cab	5.1					
Roof - Outer		Stamping	24.4	22.2	2.2	Stiffness - 75% Current
Roof - Inner		Stamping	24.4	20.5	3.9	Stiffness - 60% Current
Rear Panel		Stamping	28.7	26.1	2.6	Stiffness - 75% Current
Dash Panel		Stamping	29.4	26.8	2.6	Stiffness - 75% Current
Floor		Stamping	41.5	37.8	3.7	Stiffness - 75% Current
Door - Outer (2)		Stamping	39.0	32.8	6.2	Stiffness - 60% Current
Door - Inner (2)		Stamping	39.0	32.8	6.2	Stiffness - 60% Current
Cowl Vent Panel	5.2	Stamping	4.0	3.4	0.6	Stiffness - 60% Current
Windshield		Glass	27.0	21.5	5.5	Latest Industry Thickness Recommendation
Rear Window		Glass	11.3	7.4	3.9	Latest Industry Thickness Recommendation
Door Window (2)		Glass	18.0	11.8	6.2	Latest Industry Thickness Recommendation
Door Glass Regulator (2)	5.2	Assy.	8.0	5.0	3.0	New Cable Design - Rockwell International
Door Glass Vent Assy. (2)	5.2	Assy.	10.0	-	10.0	Eliminate - Pass. Car Practice
Hood - Outer	5.3	Stamping	28.3	23.8	4.5	Stiffness - 60% Current
Hood - Inner		Stamping	16.6	13.9	2.7	Stiffness - 60% Current
Grille Lower Panel	5.4	Stamping	3.7	3.1	0.6	Stiffness - 60% Current
Front Fender - Outer (2)	5.5	Stamping	30.4	25.5	4.9	Stiffness - 60% Current
Front Fender - Inner (2)		Stamping	14.6	13.3	1.3	Stiffness - 75% Current
Radiator Support	5.4	Stamping	39.5	35.9	3.6	Stiffness - 75% Current

Ø Less Size Reduction

TABLE 5-3 (2 of 2)

LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION
POTENTIAL SAVING BY REDESIGN

TYPE PICKUP

COMPONENTS	FIG.	PROCESS	WEIGHT (LBS.) CURRENT Ø	PROPOSED	SAVING	CRITERIA
Cargo Box	5.6					
Floor		Stamping	101.8	92.6	9.2	Stiffness - 75% Current
Front Panel		Stamping	21.0	19.1	1.9	Stiffness - 75% Current
Side Panel - Inner (2)		Stamping	42.8*	38.9	3.9	Stiffness - 75% Current
Side Panel - Outer (2)		Stamping	60.0*	50.4	9.6	Stiffness - 60% Current
Tailgate		Stamping	42.0	38.2	3.8	Stiffness - 75% Current
Frame	5.7	Stamping	345.0	310.0	35.0	Strength & Stiffness - 10% Based on more efficient utilization of material.
Engine Rear Support C/M	5.7	Stamping	19.7	17.7	2.0	Strength & Stiffness - 10% Based on more efficient utilization of material.
Rear Suspension Spring (2)	5.8	Forged	69.0	48.0	21.0	Single Leaf vs Multiple Leaf - -30% per Rockwell International.
Front Bumper		Stamping	27.3	25.3	2.0	-5% Depth
TOTAL					162.6	

Ø Less Size Reduction
* Estimated

TABLE 5-4 (1 of 3)

LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION
POTENTIAL SAVING BY MATERIAL SUBSTITUTION

TYPE Pickup

COMPONENT	FIG.	PROCESS	WEIGHT (LBS.) CURRENT Ø	PROPOSED	SAVING	SUBSTITUTE MATERIAL	CRITERIA
Cab	5.1						
Door - Outer (2)		Stamping	39.0	16.6	22.4	Aluminum	Stiffness - 60% Current
Door - Inner (2)		Stamping	39.0	16.6	22.4	Aluminum	Stiffness - 60% Current
Cowl Side (2)		Stamping	21.3	18.1	3.2	HSLA	Strength and Stiffness
Sill (2)		Stamping	17.0*	14.5	2.5	HSLA	Strength and Stiffness
Cowl Vent Panel		Stamping	4.0	1.7	2.3	Aluminum	Stiffness - 60% Current
Hood - Outer	5.3	Stamping	28.3	12.0	16.3	Aluminum	Stiffness - 60% Current
Hood - Inner		Stamping	16.6	7.1	9.5	Aluminum	Stiffness - 60% Current
Hood Hinge Bracket (2)		Stamping	10.0	8.5	1.5	HSLA	Strength and Stiffness
Grill Lower Panel	5.4	Stamping	3.7	1.6	2.1	Aluminum	Stiffness - 60% Current
Front Fender - Outer (2)	5.5	Stamping	30.4	12.9	17.5	Aluminum	Stiffness - 60% Current
Front Fender - Inner (2)		Stamping	14.6	6.7	7.9	Aluminum	Stiffness - 75% Current
Radiator Support	5.4	Stamping	39.5	18.2	21.3	Aluminum	Stiffness - 75% Current
Battery Tray		Stamping	3.0	1.4	1.6	Aluminum	Stiffness - 75% Current
Wheelhouse (2)	5.5	Stamping	21.0	10.5	10.5	Aluminum	Impact Resistance
Radiator		Stamping	14.0	7.0	7.0	Aluminum	Industry Recommendation
Heater Core		Stamping	5.0*	2.0	3.0	Aluminum	Industry Recommendation
Seat Frame	5.12	Stamping	10.0*	5.0	5.0	Aluminum	Industry Recommendation
Cargo Box	5.6						
Floor		Stamping	101.8	50.9	50.9	HMC	Stiffness - 75% Current
Floor Support Channels (5)		Stamping	52.0	44.2	7.8	HSLA	Strength and Stiffness

Ø Less Size Reduction
* Estimated

TABLE 5-4 (2 of 3)

LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION
POTENTIAL SAVING BY MATERIAL SUBSTITUTION

TYPE Pickup

COMPONENT	FIG.	PROCESS	WEIGHT (LBS.)			SUBSTITUTE MATERIAL	CRITERIA
			CURRENT Ø	PROPOSED	SAVING		
Front Panel		Stamping	21.0	9.7	11.3	Aluminum	Stiffness - 75% Current
Side Panel - Inner (2)		Stamping	42.8	19.7	23.1	Aluminum	Stiffness - 75% Current
Side Panel - Outer (2)		Stamping	60.0	25.5	34.5	Aluminum	Stiffness - 60% Current
Wheelhouse (2)		Stamping	24.0*	12.0	12.0	Aluminum	Impact Resistance
Tailgate		Stamping	42.0	19.3	22.7	Aluminum	Stiffness - 75% Current
Frame	5.7						
Sidemember (2)		Stamping	180.0*	153.0	27.0	HSLA	Strength and Stiffness
Engine Mounting Bracket (3)		Stamping	8.5	7.2	1.3	HSLA	Strength and Stiffness
Front Suspension	5.8						
Lower Control Arm (2)		Stamping	18.0	15.3	2.7	HSLA	Strength and Stiffness
Upper Control Arm (2)		Stamping	14.5	12.3	2.2	HSLA	Strength and Stiffness
Rear Suspension	5.8						
Spring Shackle (2)		Stamping	3.0	2.5	0.5	HSLA	Strength and Stiffness
Axle U-Bolt Plate (2)		1	10.0	8.5	1.5		Strength and Stiffness
Steering Gear Case	5.9	Casting	15.5	13.5	2.0	Aluminum	Actual Comparison of Assembly Aluminum vs. Cast Iron
Brake Master Cylinder	5.9	Casting	10.2	2.2	8.0	Aluminum and Plastic	New Design per Delco Moraine
Brake and Clutch Pedals		Stamping	6.0	5.0	1.0	HSLA	Strength and Stiffness
Parking Brake Pedal and Bracket		Stamping	4.0	3.4	0.6	HSLA	Strength and Stiffness
Road Wheel (5)		Stamping	107.5	80.5	27.0	HSLA	-25% per U. S. Steel

Ø Less Size Reduction
* Estimated

TABLE 5-4 (3 of 3)

LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION
POTENTIAL SAVING BY MATERIAL SUBSTITUTION

TYPE Pickup

COMPONENT	FIG.	PROCESS	WEIGHT (LBS.)			SUBSTITUTE MATERIAL	CRITERIA
			CURRENT Ø	PROPOSED	SAVING		
Fuel Tank		Stamping	21.0	10.5	10.5	Aluminum	Strength and Stiffness
Front Bumper		Stamping	25.3	12.7	12.6	Aluminum	Strength and Stiffness
Front Bumper Mounting Bracket (2)		Stamping	4.0	3.4	0.6	HSLA	Strength and Stiffness
TOTAL					415.8		

Ø Less Size Reduction

TABLE 5-5 (1 of 2)

LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION
POTENTIAL SAVING BY REDESIGN

TYPE Van

COMPONENTS	FIG.	PROCESS	WEIGHT (LBS.) CURRENT	PROPOSED	SAVING	CRITERIA
Body						
Roof	5.10	Stamping	125.0*	113.8	11.2	Stiffness - 75% Current
Dash		Stamping	33.0*	30.0	3.0	Stiffness - 75% Current
Floor		Stamping	155.0*	141.0	14.0	Stiffness - 75% Current
Side - Left		Stamping	70.0*	63.7	6.3	Stiffness - 75% Current
Side - Right		Stamping	35.0*	31.8	3.2	Stiffness - 75% Current
Front Quarter - Outer (2)		Stamping	15.0*	13.6	1.4	Stiffness - 75% Current
Front Quarter - Inner (2)		Stamping	7.0*	6.4	0.6	Stiffness - 75% Current
Underbody Structure		Stamping	250.0*	225.0	25.0	Strength and Stiffness -10% Based on More Efficient Utilization of Material
Front Door - Outer (2)		Stamping	39.0	32.8	6.2	Stiffness - 60% Current
Front Door - Inner (2)		Stamping	39.0	32.1	6.2	Stiffness - 60% Current
Side Door - Outer (2)		Stamping	28.5	23.5	5.0	Stiffness - 60% Current
Side Door - Inner (2)		Stamping	28.5	23.5	5.0	Stiffness - 60% Current
Rear Door - Outer (2)		Stamping	25.0	21.0	4.0	Stiffness - 60% Current
Rear Door - Inner (2)		Stamping	25.0	21.0	4.0	Stiffness - 60% Current
Cowl Vent Panel	5.2	Stamping	4.0	3.4	0.6	Stiffness - 60% Current
Windshield		Glass	43.5	34.6	8.9	Latest Industry Recommended Thickness
Door Window (2)		Glass	16.0	10.5	5.5	Latest Industry Recommended Thickness
Door Glass Regulator (2)		Assembly	8.0	5.0	3.0	New Cable Design -Rockwell International
Door Glass Vent Assembly (2)		Assembly	10.0	-	10.0	Eliminate Passenger Car Practice

TABLE 5.5 (2 of 2)

LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION
POTENTIAL SAVING BY REDESIGN

TYPE Van

COMPONENTS	FIG.	PROCESS	WEIGHT (LBS.) CURRENT	PROPOSED	SAVING	CRITERIA
Hood	5.11	Stamping	17.5	14.7	2.8	Stiffness - 60% Current
Front Suspension Crossmember	5.11	Stamping	36.0	32.4	3.6	Strength and Stiffness -10% Based on More Efficient Utilization of Material
Engine Rear Support Crossmember		Stamping	5.5	5.0	0.5	Strength and Stiffness -10% Based on More Efficient Utilization of Material
Seat Platform	5.12	Stamping	15.3	13.8	1.5	Strength and Stiffness -10% Based on More Efficient Utilization of Material
Rear Suspension Spring (2)	5.8	Forged	57.6	40.3	17.3	Single Leaf vs. Multiple Leaf -30% per Rockwell International
Front Bumper		Stamping	28.8	26.8	2.0	-5% Depth
Rear Bumper		Stamping	22.8	20.8	2.0	-5% Depth
TOTAL					152.8	

TABLE 5-6 (1 of 2)

LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION
POTENTIAL SAVING BY MATERIAL SUBSTITUTION

TYPE Van

COMPONENT	FIG.	PROCESS	WEIGHT (LBS.) CURRENT	PROPOSED	SAVING	SUBSTITUTE MATERIAL	CRITERIA
Body	5.10						
Front Door - Outer (2)		Stamping	39.0	16.6	22.4	Aluminum	Stiffness - 60% Current
Front Door - Inner (2)		Stamping	39.0	16.6	22.4	Aluminum	Stiffness - 60% Current
Side Door - Outer (2)		Stamping	28.5	12.1	16.4	Aluminum	Stiffness - 60% Current
Side Door - Inner (2)		Stamping	28.5	12.1	16.4	Aluminum	Stiffness - 60% Current
Rear Door - Outer (2)		Stamping	25.0	10.6	14.4	Aluminum	Stiffness - 60% Current
Rear Door - Inner (2)		Stamping	25.0	10.6	14.4	Aluminum	Stiffness - 60% Current
Cowl Vent Panel		Stamping	4.0	1.7	2.3	Aluminum	Stiffness - 60% Current
Sill - Side (2)		Stamping	28.0*	23.8	4.2	HSLA	Strength and Stiffness
Sill - Rear		Stamping	14.0*	11.9	2.1	HSLA	Strength and Stiffness
Roof Bows (4)		Stamping	26.0*	22.1	3.9	HSLA	Strength and Stiffness
Side Channels (4)		Stamping	18.0*	15.3	2.7	HSLA	Strength and Stiffness
Underbody Rails (2)		Stamping	112.0*	95.0	17.0	HSLA	Strength and Stiffness
Wheelhouse (4)			48.0*	24.0	24.0	Aluminum	Impact Resistance
Hood	5.11	Stamping	17.5	7.4	10.1	Aluminum	Stiffness - 60% Current
Radiator		Stamping	14.0	7.0	7.0	Aluminum	Industry Recommendation
Heater Core		Stamping	5.0*	2.0	3.0	Aluminum	Industry Recommendation
Seat Frame	5.12	Stamping	4.5*	2.3	2.2	Aluminum	Industry Recommendation
Seat Platform	5.12	Stamping	15.3	7.7	7.6	Aluminum	Strength and Stiffness
Engine Mounting Bracket (3)		Stamping	8.5	7.2	1.3	HSLA	Strength and Stiffness
Radiator Support Brackets (3)		Stamping	7.5	6.4	1.1	HSLA	Strength and Stiffness

* Estimated

TABLE 5-6 (2 of 2)

LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION
POTENTIAL SAVING BY MATERIAL SUBSTITUTION

TYPE Van

COMPONENT	FIG.	PROCESS	WEIGHT (LBS.) CURRENT	PROPOSED	SAVING	SUBSTITUTE MATERIAL	CRITERIA
Front Suspension	5.8						
Lower Control Arm (2)		Stamping	18.0	15.3	2.7	HSLA	Strength and Stiffness
Upper Control Arm (2)		Stamping	14.5	12.3	2.2	HSLA	Strength and Stiffness
Rear Suspension	5.8						
Spring Shackle (2)		Stamping	9.0	7.6	1.4	HSLA	Strength and Stiffness
Axle U-Bolt Plate (2)		Stamping	5.0	4.2	0.8	HSLA	Strength and Stiffness
Brake Master Cylinder	5.9	Casting	10.2	2.2	8.0	Aluminum and Plastic	New Design Per Delco Moraine
Brake and Clutch Pedals		Stamping	6.0	5.0	1.0	HSLA	Strength and Stiffness
Parking Brake Pedal and Bracket		Stamping	4.0	3.4	0.6	HSLA	Strength and Stiffness
Road Wheel (5)		Stamping	107.5	80.5	27.0	HSLA	-25% per U. S. Steel
Fuel Tank		Stamping	22.2	11.1	11.1	Aluminum	Strength and Stiffness
Front Bumper		Stamping	26.8	13.4	13.4	Aluminum	Strength and Stiffness
Front Bumper Mounting Bracket (2)		Stamping	6.5	5.5	1.0	HSLA	Strength and Stiffness
Rear Bumper		Stamping	20.8	10.4	10.4	Aluminum	Strength and Stiffness
Rear Bumper Mounting Bracket (2)		Stamping	5.0	4.2	0.8	HSLA	Strength and Stiffness
TOTAL					275.3		

TABLE 5-7 (1 of 2)

LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION
POTENTIAL SAVING BY SIZE REDUCTION

TYPE Utility

COMPONENTS	FIG.	PROCESS	WEIGHT (LBS.) CURRENT	PROPOSED	SAVING
4" WIDTH REDUCTION (2" BETWEEN WHEELHOUSES - 1" OUTBOARD EACH SIDE)					
Body	5.13				
Top		Stamping	175.0*	170.5	4.5
Dash		Stamping	32.0*	30.2	1.8
Floor		Stamping	97.0*	91.1	5.9
Tailgate		Stamping	44.0	42.0	2.0
Windshield		Glass	31.0	28.7	2.3
Rear Window		Glass	18.0*	16.4	1.6
Hood	5.3	Stamping	55.0	51.3	3.7
Radiator Support	5.4	Stamping	40.0	39.5	0.5
Grill Lower Panel	5.4	Stamping	4.0	3.7	0.3
Bumper - Front		Stamping	29.0	27.3	1.7
Bumper - Rear		Stamping	23.0	21.6	1.4
Frame (2 only)	5.7	Stamping	300.0*	295.0	5.0
Engine Rear Support	5.7				
Crossmember (2 only)		Stamping	20.5	19.7	0.8
Grill, Instrument Panel, Etc.			-	-	3.5

*Estimated

TABLE 5-7 (2 of 2)

LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION
POTENTIAL SAVING BY SIZE REDUCTION

TYPE Utility

COMPONENTS	ILL. FIG.	PROCESS	WEIGHT (LBS.) CURRENT	PROPOSED	SAVING
2" HEIGHT REDUCTION (1" ABOVE BELT - 1" BELOW BELT)					
Body	5.13				
Dash		Stamping	30.2	29.4	0.8
Cowl Side (2)		Stamping	22.0*	21.3	0.7
Side Panel (2)		Stamping	79.5*	76.1	3.4
Tailgate		Stamping	42.0	40.2	1.8
Door (2)		Stamping	80.0	78.1	1.9
Windshield		Glass	28.7	27.0	1.7
Rear Window		Glass	16.4	15.4	1.0
Door Glass (2)		Glass	16.0	15.1	0.9
Side Window (2)		Glass	35.0*	32.8	2.2
Fender (2)	5.5	Stamping	52.0	50.1	1.9
6" LENGTH REDUCTION - FRONT END SHEET METAL					
Fender (2)	5.5	Stamping	50.1	45.0	5.1
Hood	5.3	Stamping	51.3	44.9	6.4
TOTAL					62.8

* Estimated

TABLE 5-8 (1 of 2)

LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION
POTENTIAL SAVING BY REDESIGN

TYPE UTILITY

COMPONENTS	FIG.	PROCESS	WEIGHT (LBS.) CURRENT Ø	PROPOSED	SAVING	CRITERIA
Body	5.13					
Top		Stamping	170.5	155.2	15.3	Stiffness - 75% Current
Dash		Stamping	29.4	26.8	2.6	Stiffness - 75% Current
Floor		Stamping	91.1	82.9	8.2	Stiffness - 75% Current
Side - Inner (2)		Stamping	31.3	28.5	2.8	Stiffness - 75% Current
Side - Outer (2)		Stamping	44.8	37.6	7.2	Stiffness - 60% Current
Tailgate		Stamping	40.2	33.8	6.4	Stiffness - 60% Current
Door - Outer (2)		Stamping	39.0	32.8	6.2	Stiffness - 60% Current
Door - Inner (2)		Stamping	39.0	32.8	6.2	Stiffness - 60% Current
Cowl Vent Panel		Stamping	4.0	3.4	0.6	Stiffness - 60% Current
Windshield		Glass	27.0	21.5	5.5	Latest Industry Thickness Recommendation
Door Window (2)		Glass	18.0	11.8	6.2	Latest Industry Thickness Recommendation
Side Window (2)		Glass	32.8	21.5	11.3	Latest Industry Thickness Recommendation
Rear Window		Glass	15.4	10.1	5.3	Latest Industry Thickness Recommendation
Door Glass Regulator (2)	5.2	Assy.	8.0	5.0	3.0	New Cable Design - Rockwell International
Door Glass Vent Assy. (2)	5.2	Assy.	10.0	-	10.0	Eliminate - Passenger Car Practice
Hood - Outer	5.3	Stamping	28.3	23.8	4.5	Stiffness - 60% Current
Hood - Inner		Stamping	16.6	13.9	2.7	Stiffness - 60% Current
Grille Lower Panel	5.4	Stamping	3.7	3.1	0.6	Stiffness - 60% Current
Front Fender - Outer (2)	5.5	Stamping	30.4	25.5	4.9	Stiffness - 60% Current
Front Fender - Inner (2)		Stamping	14.6	13.3	1.3	Stiffness - 75% Current

Ø Less Size Reduction

TABLE 5-8 (2 of 2)

LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION
POTENTIAL SAVING BY REDESIGN

TYPE UTILITY

COMPONENTS	FIG.	PROCESS	WEIGHT (LBS.) CURRENT Ø	PROPOSED	SAVING	CRITERIA
Radiator Support	5.4	Stamping	39.5	35.9	3.6	Stiffness - 75% Current
Frame	5.7	Stamping	295.0	265.0	30.0	Strength & Stiffness -10% Based on more efficient utilization of material.
Engine Rear Support C/M	5.7	Stamping	19.7	17.7	2.0	Strength & Stiffness -10% Based on more efficient utilization of material.
Rear Suspension Spring (2)	5.8	Forging	80.0	56.0	24.0	Single Leaf vs Multiple Leaf -30% per Rockwell International
Front Suspension Spring (2)	5.14	Forging	75.0*	52.5	22.5	Single Leaf vs Multiple Leaf -30% per Rockwell International
Front Bumper		Stamping	27.3	25.3	2.0	5% Depth
Rear Bumper		Stamping	21.6	19.6	2.0	5% Depth
TOTAL					196.9	

ØLess Size Reduction
*Estimated

TABLE 5-9 (1 of 2)

LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION
POTENTIAL SAVING BY MATERIAL SUBSTITUTION

TYPE Utility

COMPONENT	FIG.	PROCESS	WEIGHT (LBS.) CURRENT Ø	PROPOSED	SAVING	SUBSTITUTE MATERIAL	CRITERIA
Body	5.13						
Door - Outer (2)		Stamping	39.0	16.6	22.4	Aluminum	Stiffness - 60% Current
Door - Inner (2)		Stamping	39.0	16.6	22.4	Aluminum	Stiffness - 60% Current
Side - Outer (2)		Stamping	44.8	19.0	25.8	Aluminum	Stiffness - 60% Current
Side - Inner (2)		Stamping	31.3	14.4	16.9	Aluminum	Stiffness - 75% Current
Tailgate		Stamping	40.2	17.1	23.1	Aluminum	Stiffness - 60% Current
Cowl Vent Panel		Stamping	4.0	1.7	2.3	Aluminum	Stiffness - 60% Current
Cowl Side (2)		Stamping	21.3	18.1	3.2	HSLA	Strength and Stiffness
Sill - Side (2)		Stamping	22.0*	18.7	3.3	HSLA	Strength and Stiffness
Sill - Rear		Stamping	11.3*	9.6	1.7	HSLA	Strength and Stiffness
Wheelhouse (2)		Stamping	24.0*	12.0	12.0	Aluminum	Impact Resistance
Hood - Outer	5.3	Stamping	28.3	12.0	16.3	Aluminum	Stiffness - 60% Current
Hood - Inner		Stamping	16.6	7.1	9.5	Aluminum	Stiffness - 60% Current
Hood Hinge Bracket (2)		Stamping	10.0	8.5	1.5	HSLA	Strength and Stiffness
Grill Lower Panel	5.4	Stamping	3.7	1.6	2.1	Aluminum	Stiffness - 60% Current
Front Fender - Outer (2)	5.5	Stamping	30.4	12.9	17.5	Aluminum	Stiffness - 60% Current
Front Fender - Inner (2)		Stamping	14.6	6.7	7.9	Aluminum	Stiffness - 75% Current
Radiator Support	5.4	Stamping	39.5	18.2	21.3	Aluminum	Stiffness - 75% Current
Battery Tray		Stamping	3.0	1.4	1.6	Aluminum	Stiffness - 75% Current
Wheelhouse (2)	5.5	Stamping	21.0	10.5	10.5	Aluminum	Impact Resistance
Radiator		Stamping	14.0	7.0	7.0	Aluminum	Industry Recommendation

Ø Less Size Reduction
* Estimated

TABLE 5-9 (2 of 2)

LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION
POTENTIAL SAVING BY MATERIAL SUBSTITUTION

TYPE Utility

COMPONENT	FIG.	PROCESS	WEIGHT (LBS.) CURRENT Ø	PROPOSED	SAVING	SUBSTITUTE MATERIAL	CRITERIA
Heater Core	5.7	Stamping	5.0*	2.0	3.0	Aluminum	Industry Recommendation
Seat Frame (2)		Stamping	12.0*	6.0	6.0	Aluminum	Industry Recommendation
Frame	5.7						
Sidemember (2)		Stamping	153.0*	130.0	23.0	HSLA	Strength and Stiffness
Engine Mounting Brackets (3)		Stamping	8.5	7.2	1.3	HSLA	Strength and Stiffness
Rear Suspension	5.8						
Spring Shackle (2)		Stamping	3.0	2.5	0.5	HSLA	Strength and Stiffness
Axle U-Bolt Plate (2)		Stamping	10.0	8.5	1.5	HSLA	Strength and Stiffness
Steering Gear Case	5.9	Casting	15.5	13.5	2.0	Aluminum	Actual Comparison of Assembly - Aluminum vs. Cast Iron
Brake Master Cylinder	5.9	Casting	10.2	2.2	8.0	Aluminum and Plastic	New Design per Delco Moraine
Brake and Clutch Pedals		Stamping	6.0	5.0	1.0	HSLA	Strength and Stiffness
Parking Brake Pedal and Bracket		Stamping	4.0	3.4	0.6	HSLA	Strength and Stiffness
Road Wheel (5)		Stamping	107.5	80.5	27.0	HSLA	-25% per U. S. Steel
Fuel Tank		Stamping	24.0	12.0	12.0	Aluminum	Strength and Stiffness
Front Bumper		Stamping	25.3	12.7	12.6	Aluminum	Strength and Stiffness
Front Bumper Mounting Bracket (2)		Stamping	4.0	3.4	0.6	HSLA	Strength and Stiffness
Rear Bumper		Stamping	19.6	9.8	9.8	Aluminum	Strength and Stiffness
Rear Bumper Mounting Bracket (2)		Stamping	5.0	4.2	0.8	HSLA	Strength and Stiffness
TOTAL					338.0		

Ø Less Size Reduction
* Estimated

TABLE 5-10 (1 of 3)

LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION
SUMMARY - POTENTIAL SAVING

TYPE Pickup

COMPONENT AREA	POTENTIAL WEIGHT SAVINGS (Lbs)			
	REDUCED SIZE	REDESIGN	MATERIAL SUBSTITUTION	TOTAL
Cab	18.0	25.0	8.0	50.4
Cab Door (2)	2.8	31.6	44.8	66.8
Hood	10.1	7.2	27.3	37.4
Radiator Support	0.5	3.6	21.3	21.8
Grill Lower Panel	0.3	0.6	2.1	2.4
Fender (2)	7.0	6.2	37.5	44.5
Cargo Box	12.0	28.4	162.3	174.3
Radiator	-	-	7.0	7.0
Heater Core	-	-	3.0	3.0
Seat Frame	5.0	-	5.0	10.0
Grill, Instrument Panel, Etc.	3.5	-	-	3.5
Frame	5.8	37.0	27.0	69.8
Front Suspension	-	-	4.9	4.9
Rear Suspension	-	21.0	2.0	23.0
Steering Gear	-	-	2.0	2.0
Brake Master Cylinder	-	-	8.0	8.0
Road Wheel (5)	-	-	27.0	27.0
Fuel Tank	-	-	10.5	10.5
Bumper	1.7	2.0	13.2	16.9
Miscellaneous Chassis Parts	-	-	2.9	2.9
	66.7	162.6	415.8	586.1

TABLE 5-10 (2 of 3)

LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION
SUMMARY - POTENTIAL SAVING

TYPE Van

COMPONENT AREA	POTENTIAL WEIGHT SAVINGS (Lbs)			
	REDUCED SIZE	REDESIGN	MATERIAL SUBSTITUTION	TOTAL
Body	-	74.2	56.2	129.8
Body Doors	-			
Front (2)	-	30.9	44.8	63.3
Side (2)	-	10.0	32.8	32.8
Rear (2)	-	8.0	28.8	28.8
Hood	-	2.8	10.1	10.1
Radiator	-	-	7.0	7.0
Heater Core	-	-	3.0	3.0
Seat Frame	-	1.5	9.8	9.8
Grill, Instrument Panel, Etc.	-	-	-	-
Front Suspension Crossmember	-	3.6	-	3.6
Front Suspension	-	-	4.9	4.9
Rear Suspension	-	17.3	2.2	19.5
Brake Master Cylinder	-	-	8.0	8.0
Road Wheel (5)	-	-	27.0	27.0
Fuel Tank	-	-	11.1	11.1
Front Bumper	-	2.0	14.4	15.1
Rear Bumper	-	2.0	11.2	12.6
Miscellaneous Chassis Parts	-	0.5	4.0	4.5
		152.8	275.3	390.9

TABLE 5-10 (3 of 3)

LIGHT DUTY VEHICLES - WEIGHT REDUCTION EVALUATION
SUMMARY - POTENTIAL SAVING

TYPE Utility

COMPONENT AREA	POTENTIAL WEIGHT SAVINGS (Lbs)			
	REDUCED SIZE	REDESIGN	MATERIAL SUBSTITUTION	TOTAL
Body	23.3	53.5	65.2	131.4
Door (2)	2.8	31.6	44.8	66.8
Tailgate	6.4	11.7	23.1	34.8
Hood	10.1	7.2	27.3	37.4
Radiator Support	0.5	3.6	21.3	21.8
Grill Lower Panel	0.3	0.6	2.1	2.4
Fender (2)	7.0	6.2	37.5	44.5
Radiator	-	-	7.0	7.0
Heater Core	-	-	3.0	3.0
Seat Frame (2)	-	-	6.0	6.0
Grill, Instrument Panel, Etc.	3.5	-	-	3.5
Frame	5.8	32.0	23.0	60.8
Front Suspension	-	22.5	-	22.5
Rear Suspension	-	24.0	2.0	26.0
Steering Gear	-	-	2.0	2.0
Brake Master Cylinder	-	-	8.0	8.0
Road Wheel (5)	-	-	27.0	27.0
Fuel Tank	-	-	12.0	12.0
Front Bumper	1.7	2.0	13.2	16.9
Rear Bumper	1.4	2.0	10.6	14.0
Miscellaneous Chassis Parts	-	-	2.9	2.9
	62.8	196.9	338.0	550.7

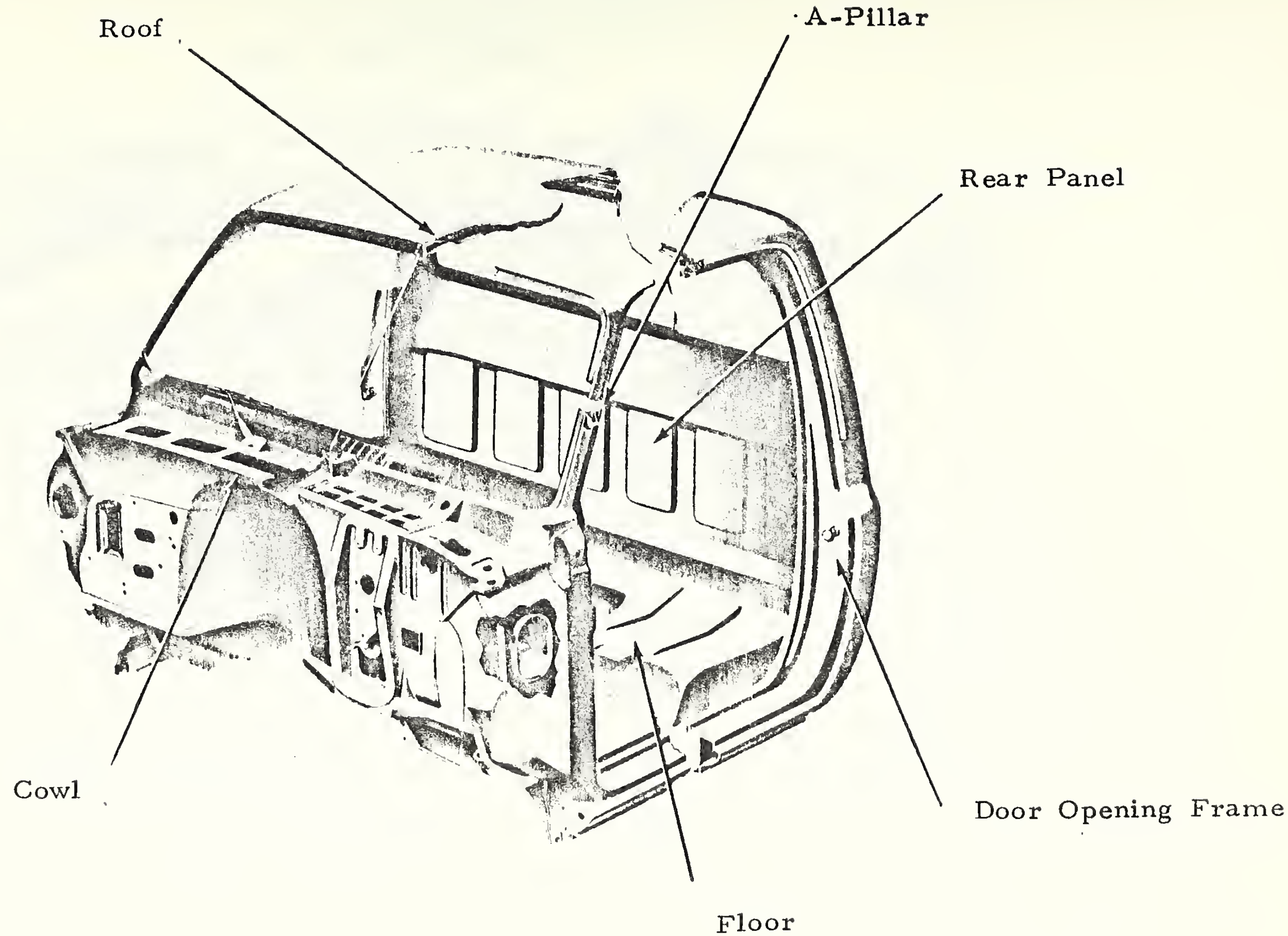


FIGURE 5-1 PICKUP CAB

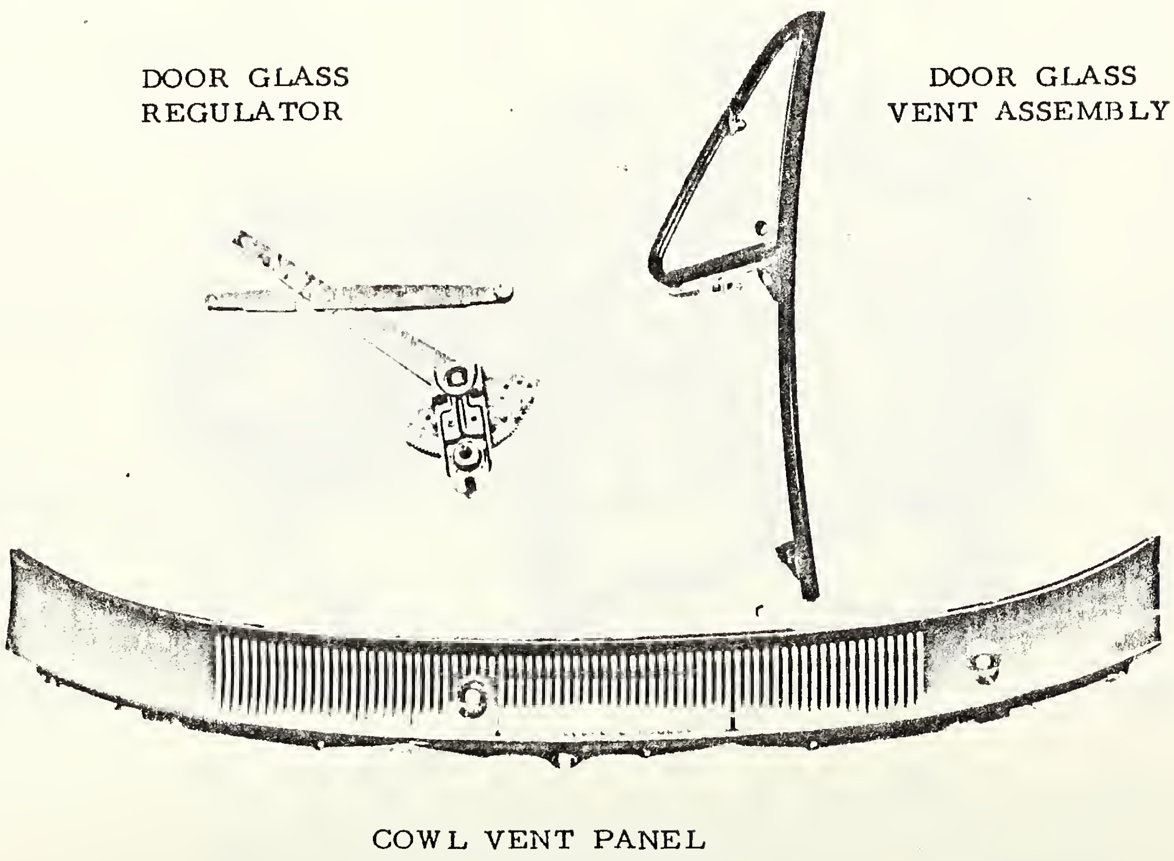


FIGURE 5-2 DOOR GLASS REGUALTOR, DOOR GLASS VENT ASSEMBLY, COWL VENT PANEL

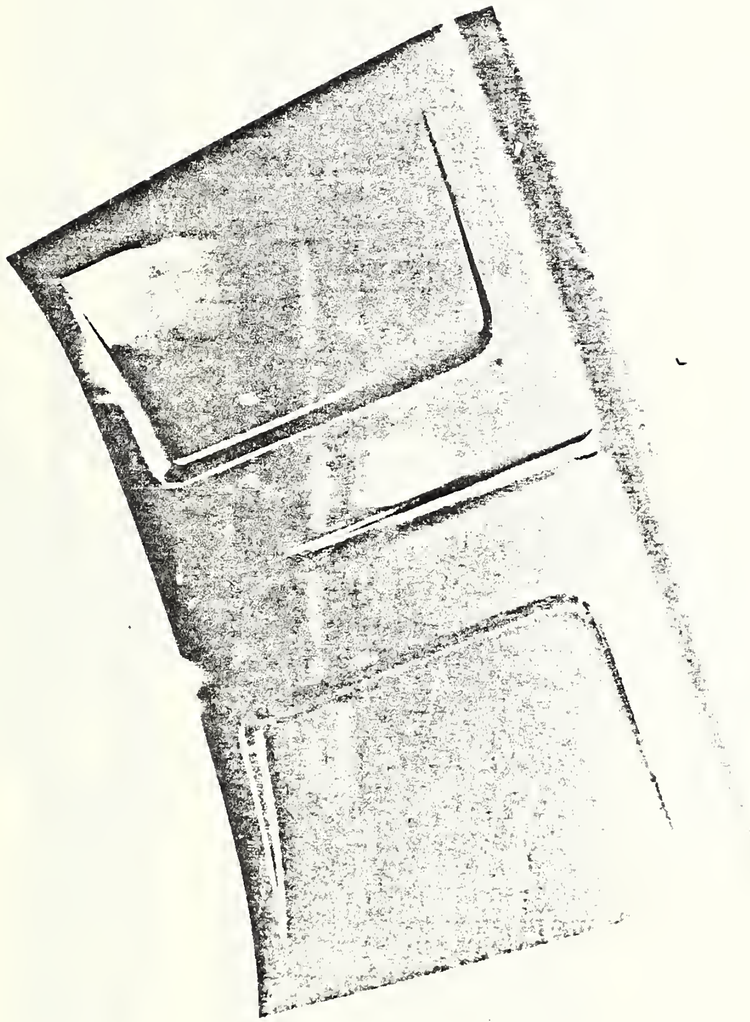
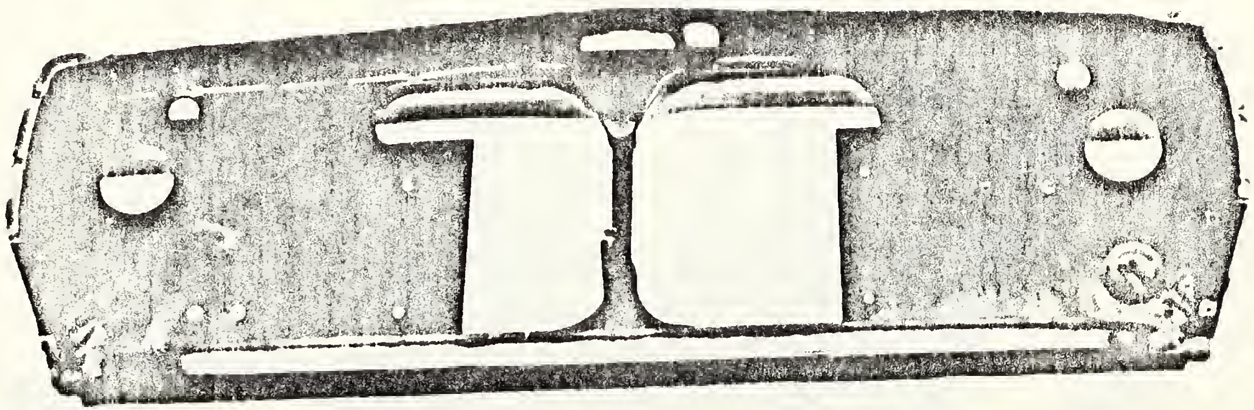


FIGURE 5-3 PICKUP HOOD

PICKUP RADIATOR SUPPORT



PICKUP GRILL LOWER PANEL

FIGURE 5-4 PICKUP RADIATOR SUPPORT AND GRILL LOWER PANEL

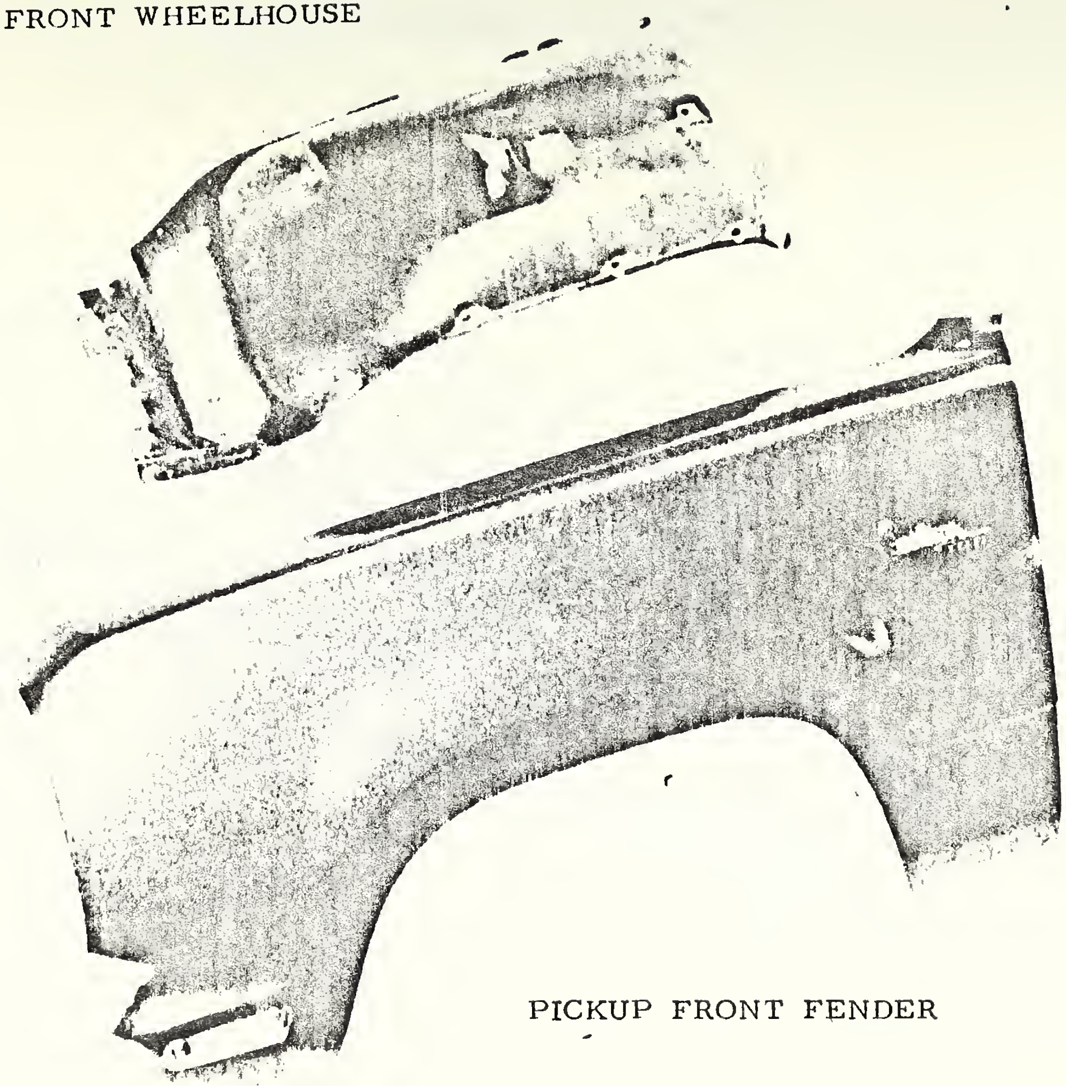


FIGURE 5-5 PICKUP FRONT WHEELHOUSE AND FRONT FENDER

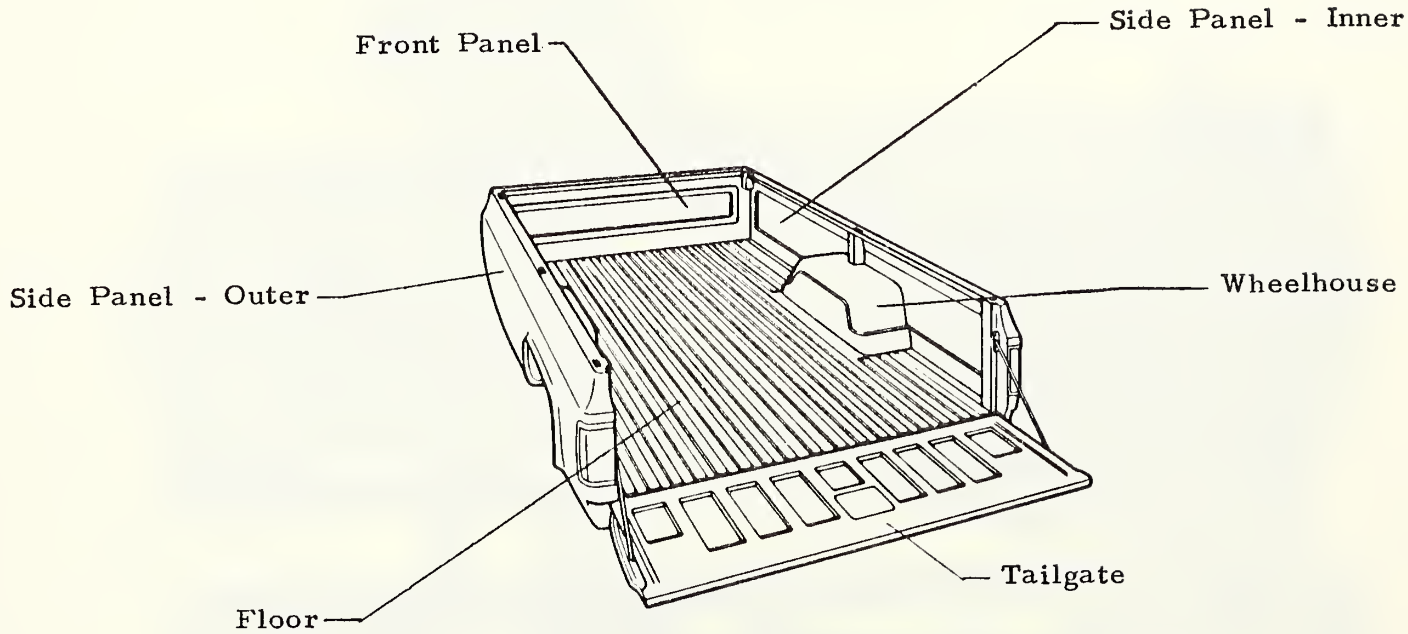


FIGURE 5-6 PICKUP CARGO BOX

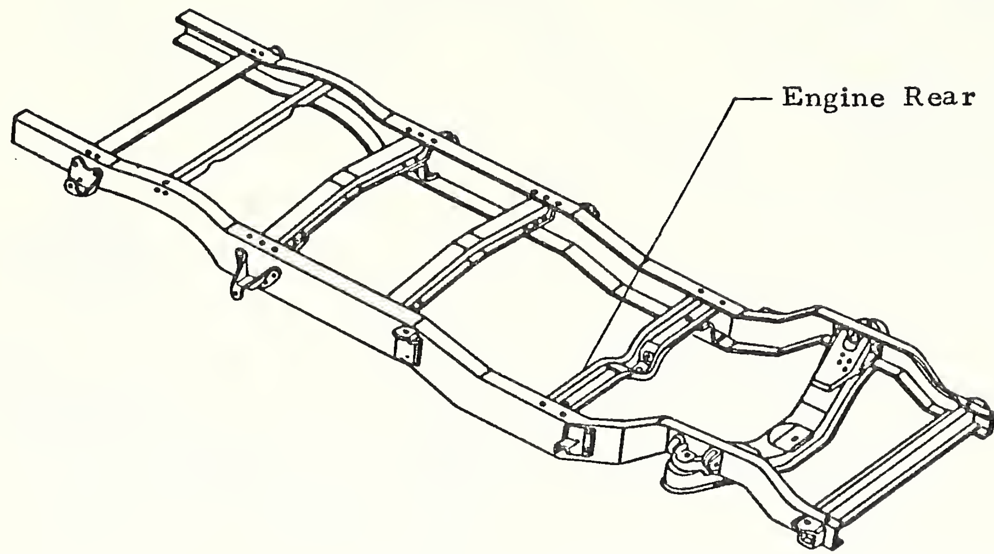
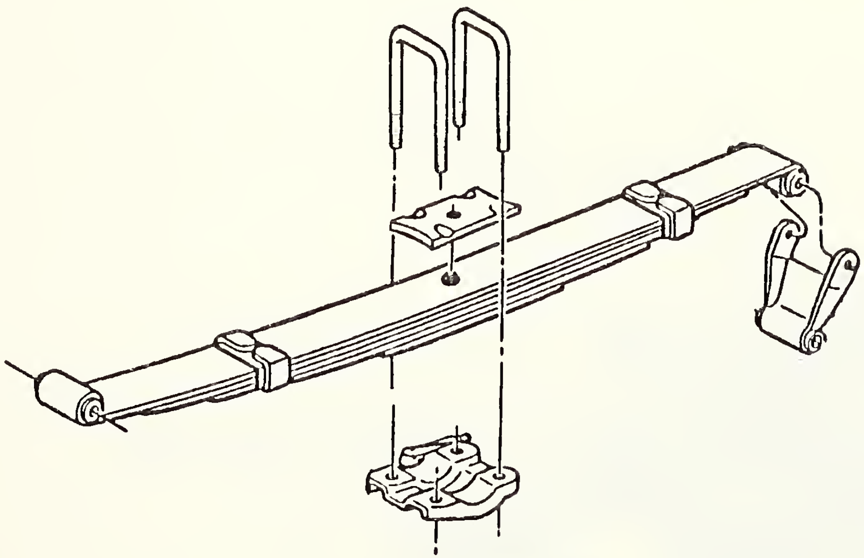


FIGURE 5-7 PICKUP FRAME



REAR SUSPENSION

FRONT SUSPENSION

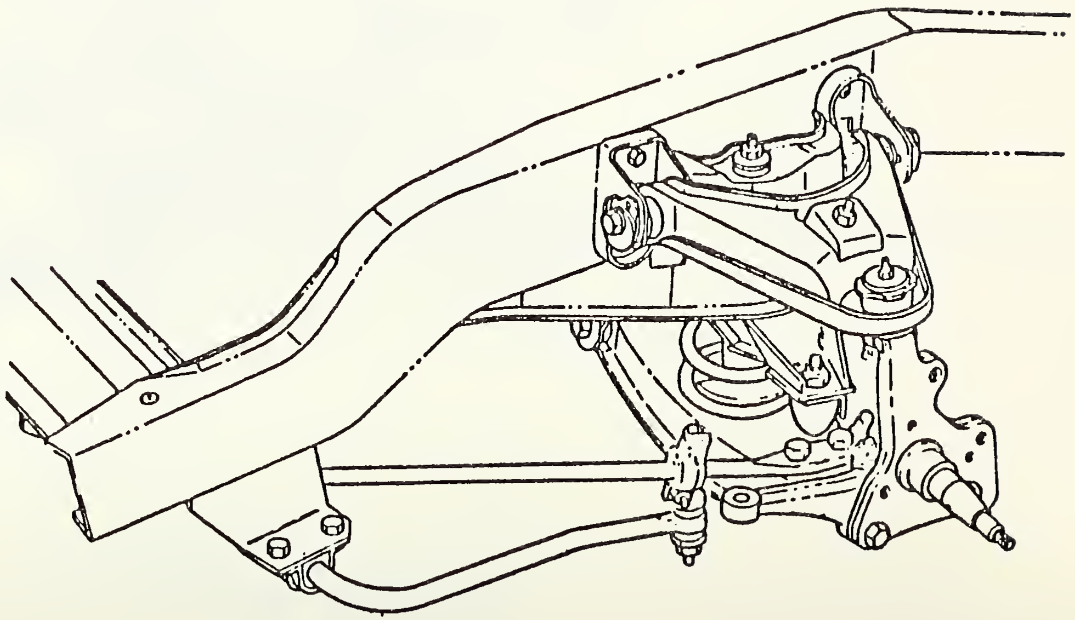
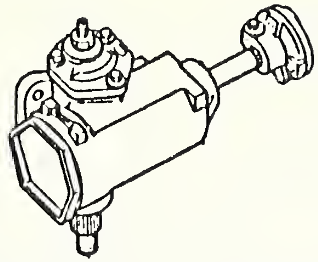
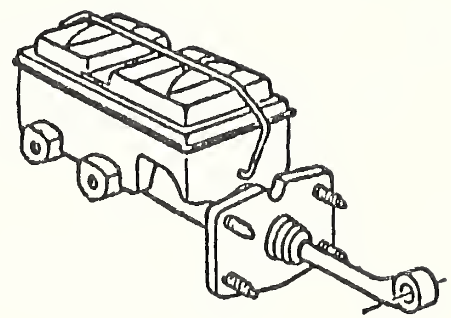


FIGURE 5-8 FRONT AND REAR SUSPENSION



MANUAL STEERING GEAR



BRAKE MASTER CYLINDER

FIGURE 5-9 MANUAL STEERING GEAR AND BRAKE MASTER CYLINDER

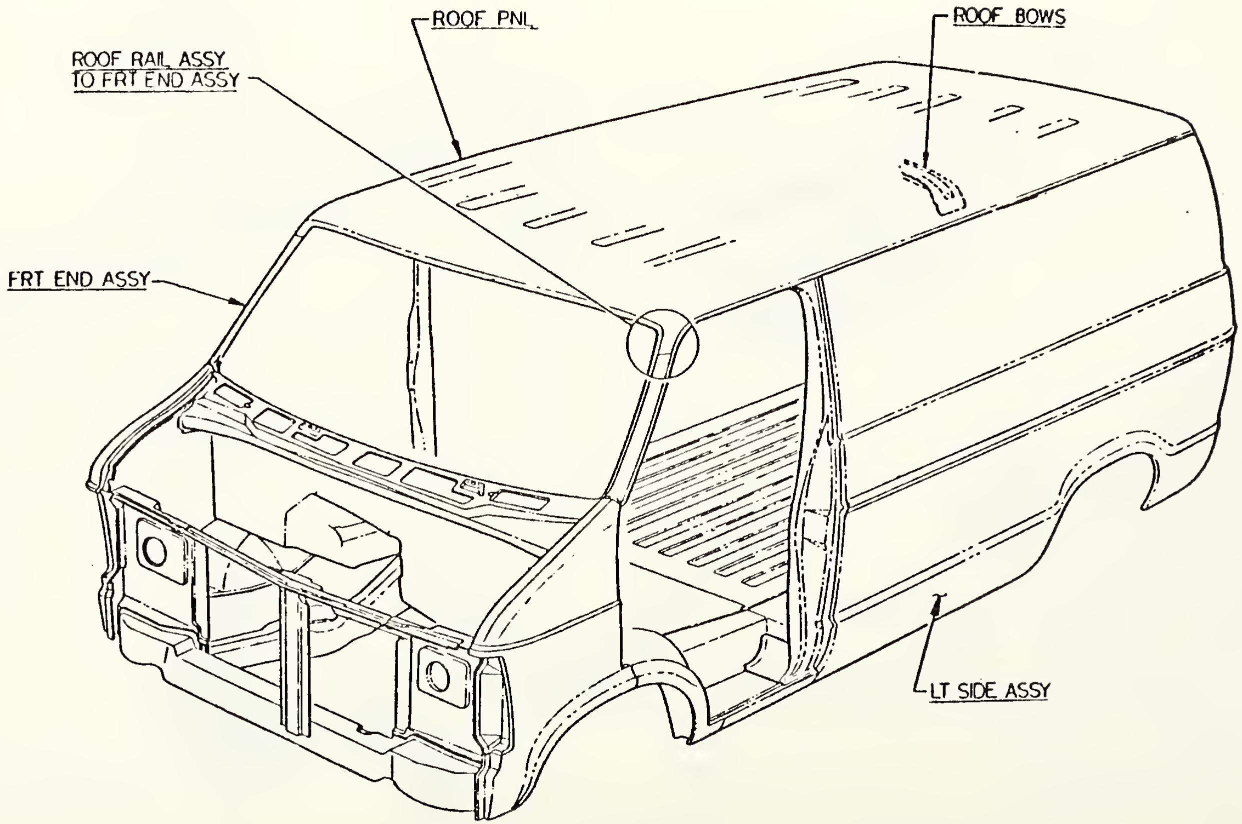


FIGURE 5-10 VAN BODY

VAN HOOD

VAN FRONT SUSPENSION CROSSMEMBER

FIGURE 5-11 VAN HOOD AND FRONT SUSPENSION CROSS MEMBER

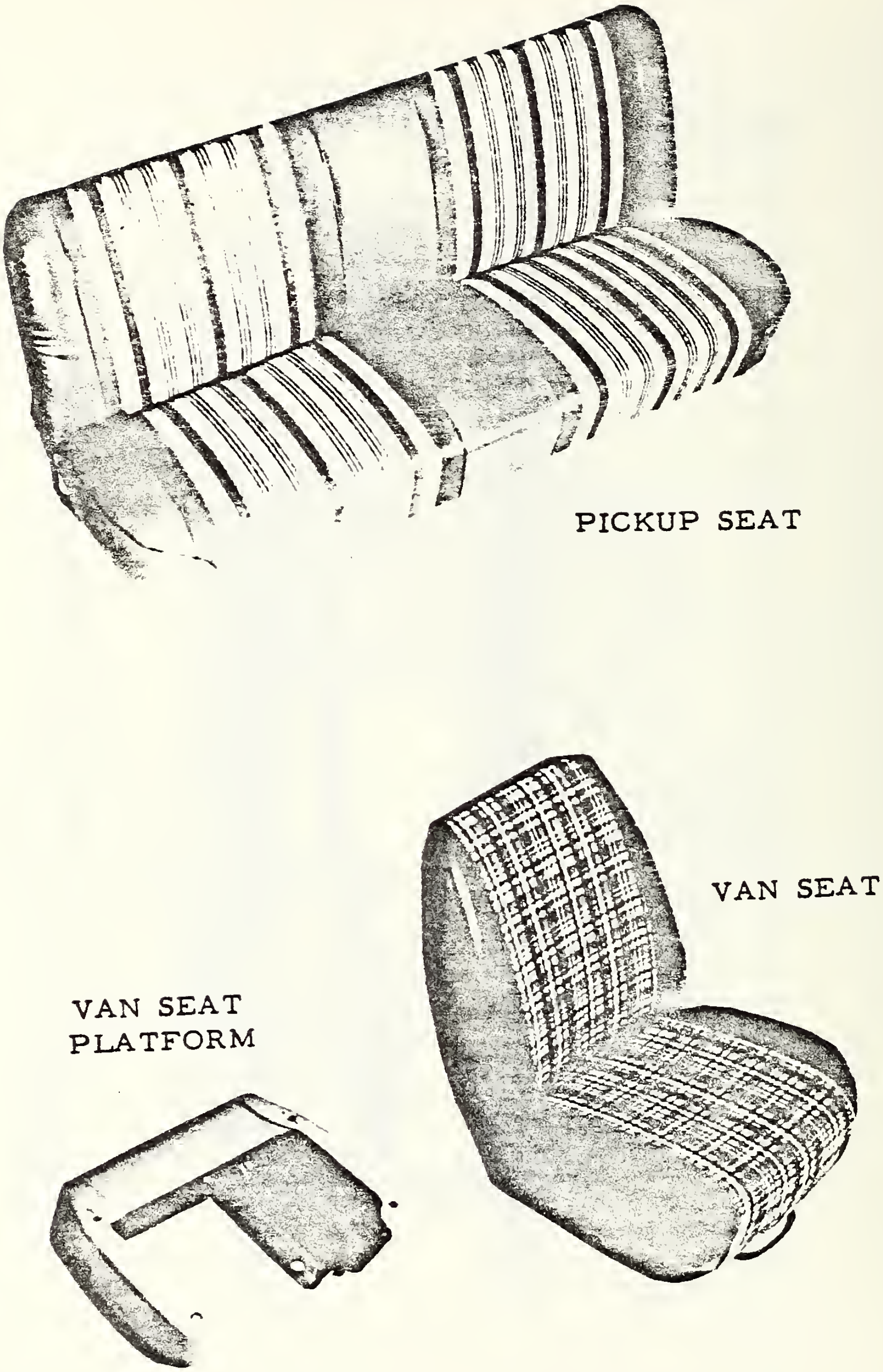


FIGURE 5-12 PICKUP SEAT, VAN SEAT AND SEAT PLATFORM

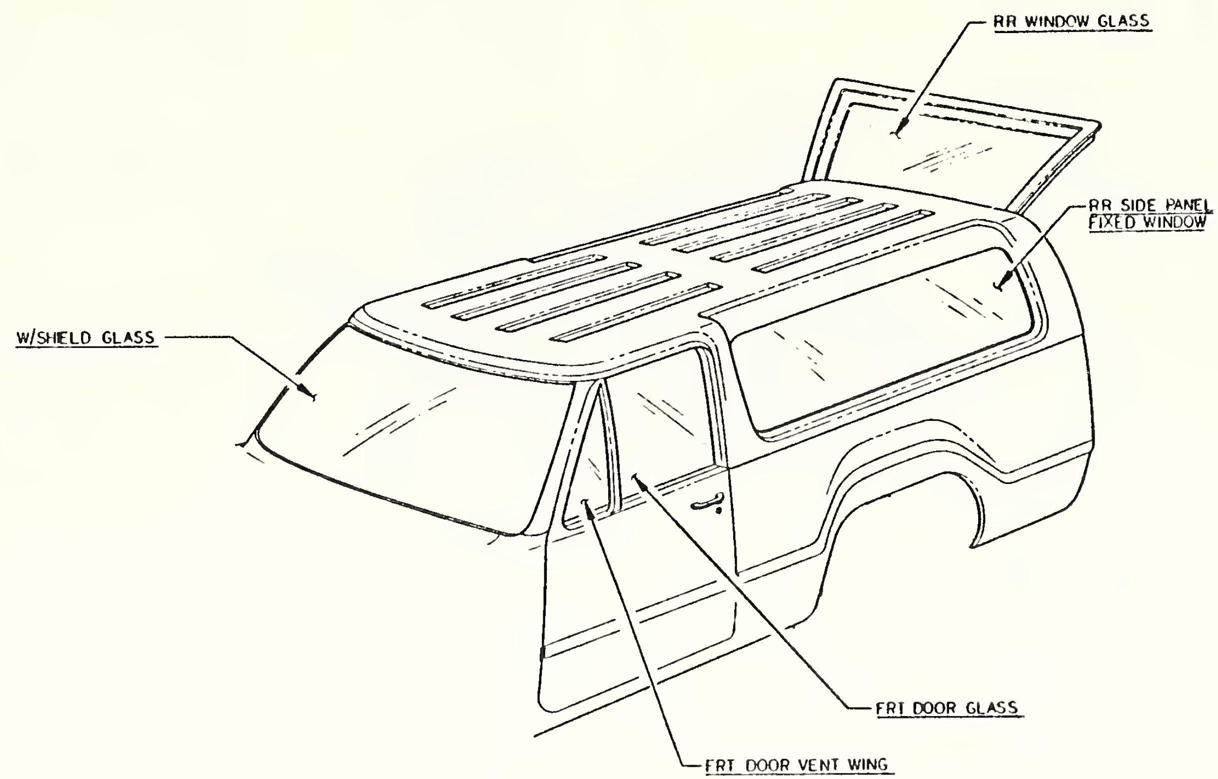


FIGURE 5-13 UTILITY BODY

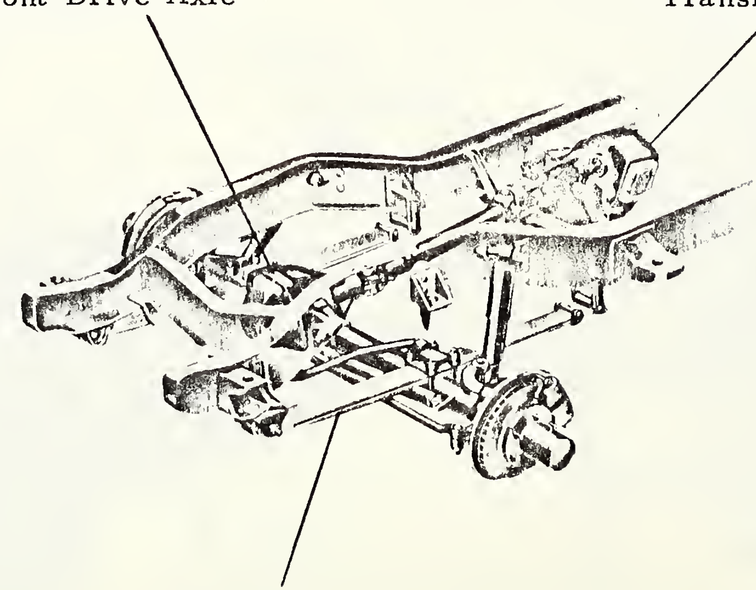


FIGURE 5-14 UTILITY FOUR-WHEEL DRIVE - FRONT SUSPENSION AND DRIVING AXLE

Note that the pickup model selected for Curb Weight and GVWR is not the lightest but is the lightest 8-foot cargo box model. This model is condisered more representative because of much higher volume than the 6-foot model. As established in Section 4.2, Load Capacity will be maintained at current levels so GVWR is reduced by a similar amount as Curb Weight.

5.6 POWER DEPENDENT WEIGHT REDUCTION

On the basis of the ground rule established in Section 4.5, light duty models at the reduced weight levels established in Section 5.5 will be provided performance levels equivalent to the minimum level of current production vehicles. As developed in Section 4.5, a performance level of 0.023, as indicated by the HP/GVWR ratio, will be maintained:

$$HP/GVWR = PF_A$$

$$HP/4400 = 0.023$$

$$HP = 0.023 \times 4400$$

$$= 101.2$$

Because of tolerances involved in estimates of this type a round number of 100 H.P. will be used.

A ratio of 1.7 CID/HP was selected for the reduced HP Engine. This represents a substantial improvement over some contemporary engines but not down to the ratio of some small high-speed 4-cyl. engines which is not considered practical. Representative current values are shown in Table 5-11.

At the ratio of 1.7 the new engine would require:

$$1.7 \times 100 = 170 \text{ CID}$$

A specific weight of 2.8 lbs./CID was selected based on the weights of the following two engines:

Plymouth 6 (1960)	170 CID	3.0 lbs./CID
Dodge Omni 4 (1978)	100 CID	2.7 lbs./CID

The value of 2.8 was selected as an anticipated saving as compared to the 1960 6-cylinder, but slightly higher than the current 4-cylinder because of the difference in engine configuration.

TABLE 5-11

CURRENT DISPLACEMENT/HORSEPOWER RATIOS

		DISP. (CID)	H.P.	CID/HP
CHEVROLET	6	250	115	2.17
	6	292	120	2.43
	V-8	305	145	2.10
	V-6	196	90	2.18
CHEVETTE	4	97.6	82	1.56
DODGE	6	225	115	1.96
	V-8	318	145	2.19
OMNI	4	104.7	75	1.40
FORD	6	300	120	2.50
	V-8	302	136	2.22
	V-6	170.8	90	1.90
	4	140	88	1.59
PONTIAC	4	151	85	1.78
VOLKSWAGEN	4	88.9	81	1.27

The specific weight of 2.8 lbs./CID, the new engine would weigh:

2.8 X 170 = 476 lbs.

Comparing the new engine estimate to the current minimum weight engine (586 pounds) gives a potential weight reduction of:

586 - 476 = 110 lbs.

The new specific weight includes most new design and material savings such as overhead cam and aluminum cylinder head and intake manifold. However, the following additional savings appear feasible:

Aluminum Cylinder Head Cover	1.7 lbs.
Aluminum Air Cleaner Body	2.3 lbs.
Stainless Steel Exhaust Manifold	12.0 lbs.
TOTAL	16 lbs.

Total engine weight saving then is:

Reduced Displacement and Design Changes	110 lbs.
Material Substitution	16 lbs.
TOTAL	126 lbs.

Since the engine and driveline on light duty trucks (at the lowest GVWR used for this analysis) are common with passenger cars, the formula developed by the Transportation Systems Center, D.O.T.* for the relationship of power dependent weight to engine CID can be employed. This formula is:

Power Dependent Weight (Pounds) = 311 + 1.92 (CID)

As a check on the validity of the formula for this application, the actual component weights of the pickup subjected to weight analysis were substituted per the development of the formula. The result gave a Power Dependent Weight of:

Engine (586 pounds less Clutch)	566 lbs.
50% Trans & Clutch	54
Cooling	41
50% Exhaust	19
20% Axle	38

*Included in the Report of the Automotive Design Analysis Panel of the Task Force on Motor Vehicle Goals beyond 1980.

80% Fuel	110
50% Battery & Alternator	25
	...
	853 lbs.

Using the power dependent weight formula, the value is:

311 + 1.92 X 250 = 791 lbs.

where: 250 = CID of current 586 pound engine.

This indicates an accuracy within the generally accepted estimating tolerance of 10 percent. The indicated saving is:

791 - (311 + 1.92 X 170) = 154 lbs.

Since an engine saving of 126 lbs. had been previously established, the formula result was modified by the percent of engine weight in the analysis, or 566/853 = 66 percent. Removing 66 percent of the previous formula value:

154 - (0.66 X 154) = 54 lbs.

left a saving of 54 lbs. for the non-engine components. The final power Dependent Saving, then, is:

126 + 54 = 180 lbs.

The same value will be used for all types since the difference in actual weight is only for the axle and the magnitude of -6 lbs. for the Van and +10 for the Utility is not considered significant. The Utility value does need to be modified for an anticipated saving in the 4-wheel drive transfer case of 110 lbs. A value of this magnitude was indicated by New Process Gear and represents an anticipated difference in weight between their current production design and a new design now under development. The new design incorporates an aluminum housing as well as other weight conscious design features.

No additional weight saving by use of an aluminum transmission case is included because it is anticipated that a 4-speed transmission will become standard on these models in order to optimize performance and economy. The 4-speed with an aluminum case should weigh about the same as the current 3-speed. While aluminum axle housings have been proposed, the information to date does not indicate this feature for 1982-5.

Hence no further weight reduction is shown for the axle.

The resultant Power Dependent Weight reduction is therefore:

WEIGHT REDUCTION - POWER DEPENDENT WEIGHT

	PICKUP	VAN	UTILITY
Engine	126 lbs.	126 lbs.	126 lbs.
Other power dependent Components	54	54	54
4-Wheel Drive Components	—	—	110
TOTAL	180	180	290

A summation of Product and Power Dependent Weight Reduction indicates a total of:

	PICKUP	VAN	UTILITY
Product Dependent	586 lbs.	391 lbs.	551 lbs.
Power Dependent	180 lbs.	180 lbs.	290 lbs.
TOTAL	766 lbs.	571 lbs.	841 lbs.

5.7 WEIGHT DEPENDENT WEIGHT REDUCTION

Weight reductions of the magnitude indicated above will obviously have a significant effect on the load carrying components of the vehicle chassis. Since the weight dependent components of the vehicles being analyzed are similar in design (many interchangeable) to passenger cars, the formula developed by TSC* should be applicable as was established for the power dependent fromula. This formula is:

$$\text{Weight Dependent Weight (pounds)} = -41 + 0.167\ (\text{GVW})$$

which gives a reduction of:

*Included in the Report of the Automotive Design Analysis Panel of the Task Force on Motor Vehicle Goals beyond 1980.

PICKUP

W (current) = -41 + 0.167 X 5000 = 794.0 lbs.
W (proposed) = -41 + 0.167 X 4240 = 667.1 lbs.

Saving = 126.9 lbs.

VAN

W (current) = -41 + 0.167 X 4600 = 727.2 lbs.

W (proposed) = -41 + 0.167 X 4030 = 632.1 lbs.

Saving = 95.1 lbs.

UTILITY

W (current) = -41 + 0.167 X 6100 = 977.7 lbs.

W (proposed) = -41 + 0.167 X 5260 = 837.4 lbs.

Saving = 140.3 lbs.

Based on previous experience these amounts appear high. Therefore, an analysis was made of the reverse propagation when minimum GVWR models are modified for higher load capacity. Since the heavier GVWR models use nonautomotive components, only the "light" models retaining automotive type components were used. The average for the big three is 8.25 lbs. load-dependent weight increase per 100 lb. increase in GVWR. This is almost exactly half the amount calculated by formula. It was decided that a value midway between the two methods should be used. This gave:

Weight Dependent Weight Reduction - lbs.	
Pickup	95
Van	71
Utility	107

5.8 SUMMARY - PRODUCT, POWER AND WEIGHT DEPENDENT WEIGHT REDUCTION

Based on the foregoing results, a summation of the total weight reduction potential that results from Product, Power and Weight Dependent components is shown below. Since the summation applies to the Curb Weight of the vehicles, by previous definition it produces an equal reduction in the GVW of the vehicles.

WEIGHT REDUCTION POTENTIAL SUMMARY - LBS.

	PICKUP	VAN	UTILITY
Product Dependent Weight	586	391	551
Power Dependent Weight	180	180	290
Weight Dependent Weight	95	71	107
TOTAL	861	642	948
GVWR	4140	3960	5150

5.9 PROPAGATION EFFECTS

Since the net reduction in GVWR is substantially higher than that used for the original determination of horsepower required to maintain performance levels, a redetermination is indicated.

Proposal (2) HP(2)/4140 = 0.023

HP (2) = 0.023 X 4140

= 95.2

The second phase engine would then be:

1.7 X 95 = 161.5 CID

and the second phase engine weight would be:

2.8 X 161.5 = 452 lbs.

with a total engine weight reduction potential of:

586 - 452 = 134 lbs.

134 + 16 = 150 lbs.

Since the new power dependent weight by formula would be:

791- (311 + 1.92 X 162) = 169 lbs.

and removal of 66 percent for the engine portion leaves 57 lbs. for the non-engine components, the new Power Dependent Weight Saving is:

150 + 57 = 207 lbs.

A second phase summation of Product and Power dependent weight reduction shows:

	PICKUP	VAN	UTILITY
Product Dependent	586 lbs.	391 lbs.	551 lbs.
Power Dependent	207	207	317
TOTAL	793	598	868

A comparison of the total weight reduction effects of phase 2 (1st stage propagation) with the initial results indicates a net change of less than 5 percent. Since this is less than half the usual tolerance on estimates of this magnitude, further propagation of weight and power dependent weights was not considered productive. Furthermore, the fact that the magnitude of the Weight Dependent weights was high by "current" practice indicated that further adjustment in these components was not advisable. A final summation of the weight reduction potential indicated by this study is therefore shown in Table 5-12.

Since it is current practice to use common Product Dependent Weight components for all models in a light truck line, the potential weight saving developed in this study should apply to all models up to 8500 GVWR. While minor variations in engine applications occur between makes (for example, Ford does not offer a 6-cylinder engine in their Utility models), the engine weight saving should also apply to all models since common engines are used. Some difference in the Weight Dependent weight saving can be anticipated because the load Capacity is held constant and it is a greater percentage of GVWR in the heavier models. However, since this portion of the potential saving is a relatively small part of the total (approximately 10 percent), the anticipated difference will have little effect on the total and can be ignored. The total Weight Reduction Potential should therefore apply to all models up to the current 8500 GVWR.

5.10 PERFORMANCE VERIFICATION

A review of the final weights for performance factors for the pickup indicated:

$$PF_A = \frac{HP}{GVWR}$$

$$= \frac{95}{4100} = 0.023 \text{ (The specified value)}$$

TABLE 5-12

WEIGHT REDUCTION EVALUATION - LBS.

LIGHT DUTY TRUCKS

SUMMARY

		PICKUP	VAN	UTILITY
Product Dependent Weight		586	391	551
Power Dependent Weight		207	207	317
Weight Dependent Weight		95	71	107
Total		888	669	975
Current Curb Weight (Minimum)		3572	3432	4277
Weight Reduction Potential		888	669	975
Potential Curb Weight		2684	2763	3302
Current GVWR (typical)		5000	4600	6100
Revised GVWR (No change in load capacity)		4100	3930	5125
Load Efficiency	Current	0.400	0.340	0.426
	Potential	0.528	0.422	0.552
Volume Efficiency	Current	2.14	5.87	2.62
	Potential	2.69	7.29	3.03
Passenger Efficiency	Current	---	1.37	1.40
	Potential	---	1.68	1.82

Torque of the new engine is calculated to be:

0.82 X 162 = 133 lb. ft.

As indicated in Table 5-13, the ratio of 0.82 is significantly better than many of today's engines but not as high as the best of the small engines. At this torque value:

$$PF_T = \frac{K_T TR(N/V)^*}{GVWR} \text{ (See Section 4.5)}$$

$$= \frac{0.23 \times 133 \times 3.00 \times 45.2}{4100} = 1.01 \text{ (With Manual Transmission)}$$

The minimal value indicates the desirability of using a 4-speed manual transmission to lower the axle ratio below 3.5 (utilized in N/V function) for improved performance including better fuel economy.

$$PF_T = \frac{0.155 \times 133 \times 4.66 \times 45.2}{4100} = 1.06 \text{ (With Automatic Transmission)}$$

The engine swept volume per ton mile is:

$$PF_S = \frac{0.6 \text{ (CID)(N/V)}}{GVWR} \text{ (See Section 4.5)}$$

$$= \frac{0.6 \times 162 \times 45.2}{4100} = 1.07$$

All values are acceptable since they are higher than 1.00.

Checks of Van and Utility models indicated PF_A values equal or better than current. PF_T values for the Van are similar. Utility values of the PF_T are comparable to current but below 1.0, indicating a need for a four-speed Manual Transmission with the 6-cylinder engine. However, since the Utility is not generally considered a commercial vehicle, the lower value may be acceptable. PF_S values are similar to current but again are below 1.0 for the Utility. This would indicate the need for a larger engine for the Utility relative to the Pickup because of higher GVWR. Since the PF_S formula penalizes the high specific output engine, its value for light duty vehicles, particularly the Utility, is subject to question. It must be recognized that the formula is intended as a guideline, and the performance on the road is the final measure of acceptance. A summation of performance factors is presented in Table 5-14.

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*Values of T(Torque), R(Transmission Low Gear Ratio) and N/V $\frac{\text{Engine RPM}}{\text{Vehicle Speed-MPH}}$ obtained from Appendix C.

TABLE 5-13

TORQUE/DISP - 1978 ENGINES

MAKE		DISP.	TORQUE	T/CID
CHEVROLET	6	250 CID	190 Ft. lbs.	0.76
	V-8	305	245	0.81
	V-6	196	165	0.84
CHEVETTE	4	97.6	82	0.84
PONTIAC	4	151	123	0.81
DODGE	6	225	170	0.75
	V-8	318	245	0.77
OMNI	4	104.7	90	0.86
FORD	V-8	302	250	0.83
	V-6	170.8	143	0.84
	4	140	118	0.84

TABLE 5-14

PERFORMANCE FACTORS

LIGHT DUTY TRUCKS

	PF_A	PF_T	PF_S
PICKUP			
Current	0.023	0.986	1.157
Reduced Weight Proposal	0.023	1.010	1.070
VAN			
Current	0.023	1.020	1.198
Reduced Weight Proposal	0.024	1.100	1.170
UTILITY			
Current	0.018	0.857	0.961
Reduced Weight Proposal	0.018	0.800	0.843

NOTE: Current values listed are the minimum for the lowest GVWR models of Chevrolet - Dodge - Ford.

5.11 OPTION WEIGHT REDUCTION

Since the ultimate purpose of vehicle weight reduction is improved fuel economy, the effect of option weights on EPA "inertia weights" must be considered. By EPA ruling, the weight of the vehicles tested for fuel economy rating must include the weight of the options on 33 percent or more of the models sold. On light duty trucks this involves the following components:

- V-8 Engines
- Automatic Transmission
- Power Brakes
- Power Steering
- Limited Slip Differential*
- Air Conditioning
- Rear Bumper (Pickup)

Tires and trim options will not be considered. Optional engines are considered in two (current) classes, approximately 300 and 350 CID. Larger engines, which are already on the way out, will not be considered.

On the basis of current levels, the new engine performance levels would be:

300 CID Class $PF_A = 0.029$

350 CID Class $PF_A = 0.034$

Revised HP required at reduced wieght levels:

HP (First Option) = 0.029 X 4100 = 119

HP(Second Option)= 0.034 X 4100 = 140

These requirements appear to coincide with current 6 and light V-8 engines. Assuming a moderate weight reduction of 50 lbs. (not a new engine design) the weight penalty for the optional engines would be:

Current 6-Cylinder Weight	= 586 lbs.
Less Assumed Reduction	50 lbs.
	536 lbs.

*Not given further consideration because of minimal weight (3 lbs.)

Less New Base Engine Weight	436 lbs.
Penalty	100 lbs.
Plus Weight Penalty for Other Power Dependent Items	57 lbs.
Total First Option Weight Penalty	157 lbs.

The second engine option weight penalty (V-8) would be:

157 + 108* = 265 lbs.

The total option weight would be:

Option	Added Weight-lbs.	Weight Saving-lbs.
Engine (1st Option)	157	50
Engine (2nd Option)	265	50
Automatic Transmission	26	—
Air Conditioning	75	15
Power Steering	25	8
Power Brakes	8	2
Rear Bumper - Pickup	20	20
Rear Bumper (Step Type)-Pickup	80	40
TOTAL (with 1st engine option and standard rear bumper)	311	95

Option	Added Weight-lbs.	Additional Weight Savings-lbs.
with 2nd engine option	+108	
with Step bumper	+ 60	+20

No weight reduction is shown for the automatic transmission since it already has an aluminum case and no significant weight reduction is anticipated. The estimated A/C reduction is based on the use of an aluminum housing for the compressor and other parts. Power Steering reflects the use of an aluminum housing for gear and pump. The Power Brake reflects the use of an aluminum housing, and the rear bumpers also are aluminum.

*Based on current differences of 108 lbs. between engines, which should still apply.

Although option weights vary slightly between makes and models, the above range of 300 to 500 lbs. provides an indication of the change from curb to inertia weight for light duty trucks.

The selection of models to be included in an "inertia weight" category is done by the manufacturer in order to avoid undue complexity in the testing program. Therefore, only the manufacturers can establish how the potential weight reductions can be used to best advantage and what the ultimate effects will be on the test inertia weight.

6. EFFECTS ON WEIGHT REDUCTION

6.1 VEHICLE COST

In general weight reduction accomplished by size reduction or improved design techniques offers a corresponding cost reduction. Some redesigns could involve more operations or handling, thus increasing labor content costs, but in most instances the material weight reduction would result in a lower part cost.

Assuming an average cost of 16.3 cents a pound for HRS and 19.3 cents for CRS, anticipated savings would be:

	PICKUP		VAN		UTILITY	
	WT(lbs)	$	WT(lbs)	$	WT(lbs)	$
Size Reduction						
CRS	43.6	8.41	—	—	40.7	7.86
HRS	12.5	2.04	—	—	8.9	1.45
GLASS						
Laminated	4.0	1.44	—	—	4.0	1.44
Tempered	3.1	0.62	—	—	5.7	1.14
Sub-Total		-12.51				-11.89
Redesign						
CRS	15.0	2.90	39.7	7.66	26.1	5.04
HRS	39.0	6.36	37.6	6.15	36.0	5.87
GLASS						
Laminated	5.5	1.98	8.9	3.20	5.5	1.98
Tempered	10.1	2.02	5.5	1.10	22.8	4.56
SubTotal		-13.26		-18.11		-17.45
Grand Total		-$25.77		-$18.11		-$29.34

Material sbustitution, on the other hand, may provide some degree of cost saving but more often in automotive applications a penalty results. The magnitude of the penalty depends on the relation of weight saved to material cost differential. U. S. Steel indicates that typical substitutions of 50,000 yield strength HSLA steel for HRS results in a 15 percent weight saving and a 10 percent cost penalty. This would indicate that only about 30% of the difference in yield strength is being realized because the

design critera involves a more complex condition than straight strength critical. This situation is true of most automotive structural components.

A summary of HSLA steel substitutions indicates penalties of:

HSLA STEEL SUBSTITUTIONS*

PICKUP	VAN	UTILITY
+$13.68	+$8.47	+$8.70

Determination of the potential cost differential between steel and aluminum is complicated by the future cost of aluminum if used in large quantities. If aluminum for body panel applications is assumed to be $1.00/lbs. vs. current CRS @ 10.3 cents/lb., then the proposed substitutions would involve a cost penalty of:

	PICKUP	VAN	UTILITY
Current Steel Weight	486 lbs.	348 lbs.	463 lbs.
Cost	$94	$67	$89
Aluminum Weight	220 lbs.	158 lbs.	210 lbs.
Cost	$220	$158	$210
Penalty	$126	$91	$121

It should be emphasized that the above penalties involve material costs only. Limited experience in handling aluminum vs. steel body panels indicated, by manufacturer's reports, that penalties as high as 1/3** of the material cost difference could be anticipated. Assuming that this factor continued at 25 percent, the penalties would be:

PICKUP	VAN	UTILITY
$158	$114	$151

Other cost differentials are estimated to be:

	PICKUP	VAN	UTILITY
Aluminum Radiator	+$ 4	+$ 4	+$ 4
Aluminum Heater Core	+ 1	+ 1	+ 1
Plastic Cargo Box Floor	+ 13	-	-
Glass	- 2.60	- 1.00	- 5.70
Engine	- 50	- 50	- 50

*Based on material costs of 16.3¢ for HRS, 10.3¢ for CRS and 24¢ for HSLA.
**Ford Motor Co. response to Proposed Rule Making on NPA Average Fuel Economy Standards for M/Y 1980-81.

Power Dependent Components	0	0	0
Weight Dependent Components	- 19	- 14	- 21
	-$53.50	-$60.00	-$71.50

The estimated material cost impact of the proposed weight reduction is therefore:

PICKUP	VAN	UTILITY
+$92.41	+$44.36	+$58.86

The above estimates have not been detailed in many cases, and the full impact of such a major change of material usage cannot be accurately assessed at this point. Burden changes, amortization costs and manufacturing differentials could all significantly to the above estimates. However, the estimates should represent an understanding of the magnitude of the manufacturing cost implications of this weight reduction project. Costs to the consumer would be significantly higher.

6.2 TOOLING IMPLICATIONS

A change in vehicle weight of the magnitude represented by this proposal could only be accomplished in conjunction with a completely new vehicle design. Assuming that the time frame of 1982 - 1985 corresponded to a scheduled major redesign, then no significant increase in the scheduled tooling costs should be required. In some cases tooling for aluminum or plastic parts could provide a cost reduction vs. tooling for steel parts.

The impact of other associated manufacturing costs, however, could be extremely costly. Use of large numbers of aluminum panels would require major changes in techniques and equipment for handling & processing parts in order to prevent damage to parts in process. Different cleaning and finishing processes would also be required. In some cases, additional heat treating and finishing operations would require new equipment and more space, aluminum bumpers for example.

The total impact of plant and equipment changes could double the normal cost of retooling a light truck line from a typical $100/$200 million (body only). These estimates are based on historical data for previous body changes. The range results from the different tooling volumes of the three manufacturers plus variations in the extent of the change (all body components or only surface panels or something in between). Unless the change corresponded to similar changes occuring in passenger car power plant, driveline and chassis components (since common components are usually

utilized), additional large expenditures would result. In fact, the feasible utilization of manufacturing facilities, as well as realistic costs, would indicate that the light duty vehicle would have to be integrated with similar programs in process for passenger cars. However, the addition of a program of this magnitude - major redesign of all light truck models - added to the current passenger car redesign programs could overtax the facilities and capital of some manufacturers.

Another complication involving timing results from announced plans of some manufacturers to have new light duty vehicles in production in 1980-81. If these fall short of the potential weight reduction indicated by this project, it would be unrealistic to expect them to completely retool again within three years. Only the individual manufacturers can adequately assess the impact of a program of this type on their schedules, manufacturing and technical facilities, and capital.

6.3 SERVICEABILITY

The extensive use of aluminum panels would require training of field service personnel in the proper handling of the material since aluminum is more easily dented or scratched than steel. Aside from possible dissatisfaction with repairs until body shops become familiar with handling aluminum this should not be a major problem for an extended period, although some increase in repair costs could be anticipated and of course new aluminum replacement parts would be considerably more expensive. Based on previous productions cost comparisions this would be in the range of 2.25 times the cost of a comparable steel part.

The major weight reduction could result in less usage of power steering and brakes. This would reduce service complexity and cost. Much wider use of 6-cylinder engines would also reduce service complexity and cost.

6.4 PUBLIC REACTION

The general acceptance of the lighter "downsized" passenger cars would indicate that the reduced weight of the trucks per se would be generally received favorably particularly since the key functional attributes are not changed. For some commercial users, the terms "light-weight" and "aluminum" might imply a reduction in durability. The manufacturer would of course insure that current levels of durability are retained. However, it could be anticipated that some percentage of the light truck market would shift to heavier models becasue of an adverse reaction to the "lightweight" concept. Providing that the new trucks can prove their dependability, this reaction should be minor and short lived.

6.5 OTHER IMPLICATIONS

The most serious question raised by the magnitude of this weight reduction potential is the assessment of the cost-benefit ratio. Many technically feasible and theoretically desirable proposals have never reached the buying public or have not been accepted by the public because the benefit did not justify the cost. If implemented, this proposal could have serious implications the the economy, the automotive industry in particular.

The additional cost added to the increases resulting from the addition of safety and emission equipment and inflation could price the vehicles out of the market for many buyers. It could lead others to buy heavier, less fuel efficient models, or to retain older, also less fuel efficient models for a longer period of time. Both would have the effect of reducing anticipated savings in fuel consumption. The large capital and technical resources required to implement an extensive program like this could force some current manufacturers out of the market or out of the business.

The ability of the material suppliers to provide the indicated quantities also needs careful assessment. The aluminum industry, for example, would not be able to provide the quantities required without extensive expansion of their facilities. The impact on electrical energy consumption for this magnitude of increased production should also be assessed. There is serious doubt whether the capacity could be available by 1982. The magnitude of the retooling required to implement these proposed changes would probably be beyond the capacity of the industry to achieve by 1982-85 considering the magnitude of concurrent changes in passenger car models. The economic impact of the steel industry resulting from the magnitude of their lost tonnage also needs to be assessed.

The possibility of encouraging wider use of "compact" size vehicles to achieve similar fuel savings without the need for such extensive material changes in full size vehicles should be evaluated. This would appear to be particularly desirable for vans where the current size needs to be retained for passenger carrying capacity.

APPENDIX A
MODEL CHARTS

A.1 AMERICAN MOTORS

The Commercial Division of American Motors has specialized in 4-wheel drive vehicles and that is all they currently manufacturer. Like the larger manufacturers, their engines are common with passenger cars. Otherwise there is negligible interchangeability. Aside from the powertrain, there is no interchangeability between the Utility models (CJ5 & CJ7) and the Pickup. Unlike the big 3 manufacturers, the AMC Utility vehicle is unique and has been developed from the World War II military model. As such it continues to provide only 2-passenger normal seating capacity. It is an extremely rugged vehicle and continues to be popular although it has had little change over the years.

The Pickup and Wagon models are interchangeable in front end sheet metal and chassis components as well as powertrain. The Wagons come in both 4-door and 2-door versions and are a rather specialized body type. Only Chevrolet offers a body style of this type (considerably larger) which is mounted on a conventional light truck chassis rather than the common truck type wagon made from a van. AMC does not offer a van type vehicle.

1978 AMERICAN MOTORS LIGHT DUTY TRUCK MODELS

MODEL	CJ5	CJ7	CHEROKEE WAGONEER	J10	J20
TYPE	UTILITY		STATION (1) WAGON	PICKUP	
DRIVE	4-WHEEL				
GVWR RANGE	3750 4150	3750 4150	6200	6200	6800 8400
WHEELBASE	83.5	93.5	108.7	118.7 130.7	130.7
CAB	A	A	-	B	B
FESM	A	A	B	B	B
STRUCTURE	FRAME AND BODY				
ENGINE	232-6 258-6 304-V8		258-6 360-V8 401-V8	258-6 360-V8 401-V8	360-V8 401-V8
TRANSMISSION TYPE RATIOS	MAN-3 MAN-4	MAN-3 MAN-4 AUTO-3	MAN-3 MAN-4 AUTO-3	MAN-3 MAN-4 AUTO-3	MAN-3 MAN-4 AUTO-3
REAR AXLE RATIOS	3.54 4.09	3.54 4.09	3.07 3.54 4.09	3.54 4.09	3.73 4.09
TRANSFER CASE RATIOS	2.0 to 1 1.0 to 1				

REMARKS:

(1) 2-Door or 4-Door Models are available on Cherokee
All Wagoneer Models are 4-Door

NOTE: Not all Engine, Transmission, and Rear Axle Ratios are available together or with all GVW Ratings.

A.2 CHEVROLET

The largest manufacturer of passenger cars also holds a similar distinction in the light truck field. Engines and some powertrain and chassis components (on lightest GVWR models) are common with passenger cars. All conventional layout models (Pickup, Utilities and Station Wagons) use common front end sheet metal cab components and share many chassis components except as required for wheelbase or load capacity differences. The chassis and cab from the Pickup are also offered without a body for mounting specialized body types. All models are available in both 2- and 4-wheel drive versions.

Van and Van-Wagons use a common base body with windows, seats and more complete interior trim added for the Wagon version. While powerplant, driveline and some chassis components are common with other light truck models, the Van has a completely different body design from the conventional layout models. It has a unitized rather than separate frame and body and the driver/front passenger seating positions are forward alongside the engine. This semi-forward control seating position shortens overall length and eliminates the conventional hood and front fenders. All U.S. Vans use a semi-forward control position in which the driver is essentially behind the front wheels. The first U.S. Van models (as well as most foreign models) used a forward control position in which the driver's legs extended ahead of the wheels. This position is no longer considered acceptable from a frontal impact standpoint.

As noted on the accompanying chart, Chevrolet offers 3 cab types and two cargo box lengths as well as two different constructions for the Pickup. There are also two body lengths for the Van and Van-Wagons. Utility models are offered in only one size but are available with either hard or soft top.

Two conventional In-line 6-cylinder and several V-8 options are offered. The 292 CID 6 is only offered on trucks. A V-8 diesel is offered as an option in Pickups. Manual (3- or 4-speed) and automatic transmissions are offered. Independent front suspension is used for all 2-wheel drive models (except step vans) while 4-wheel drive uses a solid axle with leaf springs. Front disc and rear drum brakes are specified for all models and power assist is standard in the higher GVWR models. Power Steering, air conditioning and a wide range of other options are available.

Chevrolet also offers an imported compact Pickup (built in Japan) and a specialized Pickup with the FESM and many other components from the intermediate passenger car.

Chevrolet offers a unique model known as a step van. It features a semi-forward control and a low floor in the driver's compartment to facilitate entry and exit in urban multi-stop delivery service. The body is van type but larger and completely different from the regular Van models.

GMC models are identical with Chevrolet except for nameplate and minor trim items.

1978 CHEVROLET LIGHT DUTY TRUCK MODELS

MODEL	LUV	EL CAMINO	C10	C10/F44	C20	C30	K10	K20	K30	SUBURBAN		G10	G20	G30	G10	G20	G30	C10	K10
TYPE	PICKUP									STATION WAGON		VAN			VAN WAGON			UTILITY	
DRIVE	2 WHEEL						4 WHEEL			2W	4W	2 WHEEL						2W	4W
GVWR	3950	4424	4900	6050	6400	6600	6200	6800	8600	6050		4900	6400	6400	5600	6400	6600	6050	6200
RANGE		4674	5600	6200	8200	10000		8400	10000	8400		6000	6600	6600	8400	6000	6600	8150	
WHEELBASE	102.4	117.1	117.5	117.5	131.5	131.5	117.5	131.5	131.5	129.5	129.5	110	110	110	110	110	125	106.5	106.5
			131.5	131.5	164.5	135.5	131.5		135.5	125	125	125	125	125	125	125			
						159.5			159.5										
						164.5			164.5										
CAB	A	B	C(1)							E		D						C	
FESH	A	B(2)	C									D						C	
STRUCTURE	FRAME AND BODY (3)									UNITIZED								FRAME AND BODY	
ENGINE	110.8-4	200-6	250-6	250-6	292-6		250-6	292-6		250-6	305-V8	250-6	292-6		250-6	292-6		250-6	250-6
DISP.-CYL.			305-V8				350-V8			305-V8	305-V8	305-V8	350-V8		305-V8	305-V8		305-V8	305-V8
D-DIESEL		350-V8	350-V8	454-V8		454-V8	400-V8		400-V8	350-V8	400-V8	350-V8	400-V8		350-V8	400V8		350-V8	350-V8
			454-V8							454-V8									400-V8
			350-V8D																
TRANSMISSION	MAN-4	MAN-3				MAN-4	MAN-3		MAN-4	MAN-3									
TYPE-RATIOS	AUTO-3	MAN-4				AUTO-3	MAN-4		AUTO-3	MAN-4		AUTO-3						MAN-4	
		AUTO-3					AUTO-3											AUTO-3	
REAR AXLE	4.10	2.73	3.07	3.40	4.10		4.11	4.10	4.56	2.76		3.08	3.40	4.09	3.08	3.40	4.09	4.11	
		2.41	3.73	4.11	4.56		3.73	4.56	4.10	3.07		3.73	3.73	4.56	3.73	3.73	3.75	3.73	3.73
			3.40	3.73	3.73		3.40	3.73		3.21		3.42	3.07	3.75	3.42	3.07	3.21	3.07	3.40
			2.76	3.07	3.21		3.07			3.40		2.73	2.76	3.21	2.73	2.76			3.07
				2.76			2.76			3.73									2.76
																			4.11
																			4.56
TRANSFER CASE RATIOS								2.0 TO 1											2.0 TO 1
								1.0 TO 1											1.0 TO 1

REMARKS:

(1) AVAILABLE AS: 2-DOOR CONVENTIONAL CAB, 4-DOOR CLUB CAB, 4-DOOR CREW CAR (6 PASSENGER)
(2) FESH COMMON WITH THE INTERMEDIATE PASSENGER CAR
(3) PICKUPS ARE AVAILABLE AS SMOOTH SIDE OR SEPARATE FENDER CARGO BOX

NOTE: CAB AND CHASSIS VERSIONS ARE AVAILABLE ON THE LUV AND MOST C & K MODELS.
G MODELS ARE AVAILABLE WITH FRONT BODY SECTION AND REAR PLATFORM FOR INSTALLATION OF SPECIAL VAN AND MOTOR HOME BODIES.
CHEVROLET OFFERS A SEMI-FORWARD CONTROL CHASSIS SERIES FOR INSTALLATION OF "STEP-VAN" DELIVERY BODIES WITH GVW RANGE OF 6200# to 10,000#.
NOT ALL ENGINE, TRANSMISSION, AND REAR AXLE RATIO COMBINATIONS ARE AVAILABLE WITH ALL GVW RATINGS AND ALL WHEEL BASES.

A.3 DODGE

Since the big 3 manufacturers have very competitive and comparable lines in the light truck field, to avoid repetition, only those areas where Dodge and Ford are unique or different will be covered. Unlike Chevrolet and Ford, Dodge has dropped out of the Medium and Heavy Truck fields and has concentrated its efforts in the Light Truck Market.

Dodge uses engines and some powertrain and chassis components common with passenger cars, but their engine offerings are not as extensive as Chevrolet. Dodge does offer a 6-cylinder imported diesel engine as an option on Pickups. Pickups and Utility models have common front end sheet metal and many other components. A conventional chassis Station Wagon is not offered. The Van has been a particularly successful model with Dodge and like the Chevrolet model it is unitized. Dodge is unique in offering an extended body (without increase in wheelbase) Van (Maxi-Van) that provides extra cargo or passenger capacity. Maximum passenger capacity is 15, as compared to 12 for other models. The Utility model comes without a top as well as with a hard top option. The soft top is only available as a dealer installed item.

Although basically similar in design concept to the Chevrolet, Dodge components in general seem to be slightly lighter to account for its lighter overall weight. The exact differences cannot be established in detail without the benefit of a tear-down analysis. Front suspension components were compared and the Dodge parts were uniformly lighter. The designs are the same in principle but differ in detail.

Dodge is unique in offering a 4-speed manual transmission with overdrive (4th) as an option on some Pickup and Van models.

Dodge does not offer either an imported compact Pickup or passenger car derivative.

1978 DODGE LIGHT DUTY TRUCK MODELS

MODEL	D100	D150	D200	D300	W150	W200	W300	B100	B200	B300	B100	B200	B300	AD100	AW100
TYPE	PICKUP							VAN			VAN-WAGON			UTILITY	
DRIVE	2 WHEEL				4 WHEEL			2 WHEEL						2 WHEEL	4 WHEEL
GVWR RANGE	5000 5500	6100	6200 9000	6600 10000	6100	6900 8000	8500 10000	4600 5500	6100 6400	6400 8200	4800 5500	6100 6400	6700 7700	6100	6100
WHEELBASE	115 131 133 149	115 131 133 149	131 149 165	131 149 165	115 131 133 149	131 149	135	109 127	109 127	109 127	109 127	109 127	109 127	106	106
CAB	A (1)							B						A	
FESM	A							B						A	
STRUCTURE	FRAME AND BODY (2)							UNITIZED						FRAME AND BODY	
ENGINE DISP.-CYL. D = DIESEL	225-6 318-8 360-8	225-6 318-8 360-8 400-8 440-8 243-6D		225-6 318-8 360-8 400-8 440-8	225-6 318-8 360-8 400-8 440-8 243-6D		225-6 318-8 360-8 400-8 440-8 243-6D	225-6 318-8 360-8	225-6 318-8 360-8 400-8 440-8		225-6 318-8 360-8	225-6 318-8 360-8 400-8 440-8	318-8 360-8 400-8 440-8	225-6 318-8 360-8 400-8	225-6 318-8 360-8 400-8 440-8
TRANSMISSION TYPE - RATIOS	MAN-3 MAN-4 O.D. MAN-4 AUTO-3		MAN-3 MAN-4 AUTO-3	MAN-4 AUTO-3	MAN-3 MAN-4 AUTO-3		MAN-4 AUTO-3	MAN-3 MAN-4O.D. AUTO-3	MAN-3 AUTO-3		MAN-3 MAN-4 O.D. AUTO-3	MAN-3 AUTO-3	AUTO-3	MAN-3 AUTO-3	MAN-3 MAN-4 AUTO-3
REAR AXLE RATIOS	3.55 3.2 2.71	3.55 3.2 3.9 2.71	4.10 3.54	4.10 4.56 4.88	3.55 3.2 3.9	4.10 3.54	4.88	3.5 3.2 2.7		4.1 3.5	3.5 3.2 2.7		4.1 3.5	3.55 3.2 3.9	
TRANSFER CASE RATIOS					2.0 to 1 1.0 to 1										2.0 to 1 1.0 to 1

REMARKS:

(1) AVAILABLE AS: 2-DOOR COVENTIONAL CAB
2-DOOR CLUB CAB
4-DOOR CREW CAB (6 PASS.)

(2) PICKUPS ARE AVAILABLE WITH SMOOTH SIDE OR SEPARATE FENDER CARGO BOX.

NOTE: CAB AND CHASSIS VERSIONS ARE AVAILABLE ON MOST D & W MODELS.
B MODELS ARE AVAILABLE WITH FRONT BODY SECTION AND REAR PLATFORM FOR INSTALLATION OF SPECIAL VAN AND MOTOR HOME BODIES.
B200 & B300 - 127IN. WHEELBASE MODELS ARE AVAILABLE WITH 18" ADDED LENGTH "MAXI-VAN" BODIES.
NOT ALL ENGINE, TRANSMISSION & REAR AXLE RATION COMBINATIONS ARE AVAILABLE WITH ALL GVW RATINGS AND ALL WHEELBASES.

A.4 FORD

In spite of its major effort to increase its share of the heavy truck field, Ford is still a major competitor in the light truck field. It is unique in offering only a large displacement (300 CID) 6 in addition to an extensive offering of V-8s.

The Ford Van is different from Chevrolet and Dodge in that it has separate frame and body construction. It also has a modified forward control in which the driver is not as far forward and the engine housing does not intrude as far into the driver's compartment. The design results in a longer and heavier design for a given size cargo area.

The Ford Utility model is also smaller than Chevrolet or Dodge and is available only with 4-wheel drive and hard top. Although Ford has a basic design similar to its competitors, its front suspension design - called Twin I-Beam - is unique and heavier than its competitors.

1978 FORD LIGHT DUTY TRUCK MODELS

MODEL	COURIER	RANCHERO	F100	F150	F250	F350	F150	F250	E100	E150	E250	E350	E100	E150	E250	U150
TYPE	PICKUP								VAN				VAN-WAGON			UTILITY
DRIVE	2 WHEEL						4 WHEEL		2 WHEEL							4 WHEEL
GVWR	3951 4011	5255	4800 5800	6050 6400	6200 8100	6600 10000	6050 6500	6800 8500	5150 5750	5100	5640 8250	0550 9900	5500 6000	6200 6700	6800 8900	6010 6550
WHEELBASE	106.9 112.8 138.8 155	118 155	117 133 150.3 155	133 138.8 155 161 166.5	133 138.8 155	137 140 155	117 133	133 150.3	124 138	124 138	138	138	124	124 138	138	104
CAB	A	B	C (1)						D							C
FESM	A	B (2)	C						0							C
STRUCTURE	FRAME AND BODY															
ENGINE	109.8-4 140.3-4	302-V8 351-V8 400-V8	300-6 302-V8 351-V8 400-V8	300-6 302-V8 351-V8 400-V8 460-V8		300-6 351-V8 400-V8 460-V8	300-6 351-V8 400-V8		300-6 351-V8 460-V8							351-V8 400-V8
TRANSMISSION TYPE RATIOS	MAN-4 MAN-5 AUTO-3	AUTO-3	MAN-3 MAN-4 MAN-40,D AUTO-3			MAN-4 AUTO-3			MAN-3 MAN-40,D AUTO-3			MAN-3 AUTO-3	MAN-3 MAN-40,D AUTO-3			MAN-4 AUTO-3
REAR AXLE RATIOS	3.64	2.75 2.50 3.00	2.75 3.00 3.25 3.50	3.00 2.75 3.25 3.50	3.73 3.07 3.31 3.54 4.10	4.10 3.73 4.56	3.50 3.00 4.11	3.54 4.10	2.75 3.00 3.25	3.00 2.75 3.25 3.50	3.73 3.07 3.31 4.10	4.10 3.73	2.75 3.00 3.25 3.50	3.00 2.75 3.25 4.10	3.73 3.07 3.31	3.50 3.00 4.11
TRANSFER CASE RATIOS							2.0 TO 1 1.0 TO 1									

REMARKS: (1) Available as: 2-Door Conventional Cab, 4-Door Club Cab, 4-Door Crew Cab (6-Passenger)
(2) FESM Common with the Intermediate Passenger Car.
(3) Pickups are available with Smooth Side of Separate Fender Cargo Box.

NOTE: E Models are available with Front Body Section and Frame for installation of Special Van and Motor Home Bodies.
Not all Engine, Transmission, and Rear Axle Ratio Combinations are available with all GVW Ratings and all Wheelbases.

A.5 INTERNATIONAL

International, unlike the other manufacturers, has no passenger car models to share components with. It is also the only one offering a 4-cylinder engine as standard and the range of engine options is limited. A 4-cylinder diesel is offered as an option.

This manufacturer has traditionally concentrated on the heavy duty field and has recently withdrawn from the light duty field. It offers only a Utility vehicle and a Pickup derivative which is not directly competitive with conventional Pickups. Both 2- and 4-wheel drive models are offered. The Utility is smaller than models offered by the big 3 but larger than AMC Jeeps. It is available without top or with soft or hardtop.

MODEL	TRAVEL TOP	TRAVELER	TERRA	SS II
TYPE	STATION WAGON		PICKUP	UTILITY
DRIVE	2 WHEEL OR 4 WHEEL			
GVWR RANGE	6200			
WHEELBASE	100	118	118	100
CAB	A			
FESM	A			
STRUCTURE	FRAME AND BODY			
ENGINE DISP.-CYL. D-DIESEL	196-4 198-6 304-V8 345-V8			196-4 304-8 345-8
TRANSMISSION TYPE-RATIOS	MAN-3 MAN-4 AUTO-3			
REAR AXLE	3.07 3.54 3.73 4.09			
TRANSFER CASE RATIOS	2.0 to 1 1.0 to 1			

NOTE: Not all Engine, Transmission, and Rear Axle Ratios are available together.

APPENDIX B

LOAD, VOLUME & PASSENGER CAPACITIES
LIGHT DUTY VEHICLES

MAKE AMERICAN MOTORS

YEAR 1978

TYPE	PICK UP					UTILITY	
	CONVENTIONAL CAB					HARD TOP*, NO REAR SEAT	
	4 WHEEL DRIVE					4 WHEEL DRIVE	
MODEL	J10		J20			CJ5	CJ7
GVWR (LBS.)	6200		6800	7600	8400	4150	4150
WHEELBASE (IN.)	118.7	130.7	130.7	130.7	130.7	83.5	93.5
CURB WEIGHT (LBS.)	3831	3898	4269	4285	4379	2988	3033
LOAD CAPACITY (LBS.)	2369	2302	2531	3315	4021	1162	1117
VOLUME CAPACITY (FT.^{3})	67.0	76.6	76.6	76.6	76.6	10.2	13.6
LENGTH (IN.)	83.6	95.6	95.6	95.6	95.6	N.A.	N.A.
WIDTH (IN.)	68.0	68.0	68.0	68.0	68.0	N.A.	N.A.
HEIGHT (IN.)	20.5	20.5	20.5	20.5	20.5	N.A.	N.A.
PASSENGER CAPACITY	3	3	3	3	3	2	2
LOAD EFFICIENCY	0.618	0.591	0.593	0.774	0.918	0.389	0.368
VOLUME EFFICIENCY X 10^2	1.75	1.95	1.78	1.78	1.75	0.341	0.448
PASSENGER EFFICIENCY X 10^3						0.67	0.66

NOTE: ALL MODELS WITH STANDARD EQUIPMENT EXCEPT AS NOTED

* NOT STANDARD EQUIPMENT

LOAD, VOLUME & PASSENGER CAPACITIES
LIGHT DUTY VEHICLES

MAKE CHEVROLET

YEAR 1978

TYPE	PICKUP																
	CONVENTIONAL CAB - FLEETSIDE																
MODEL	C-10						C-10/F-44				C-20				C-30		
GVWR	4900		5400		5600		6050		6200		6400	7100	7500	8200	6600	7400	8200
WHEELBASE	117.5	131.5	117.5	131.5	117.5	131.5	117.5	131.5	117.5	131.5	131.5	131.5	131.5	131.5	131.5	131.5	131.5
CURB WEIGHT (LBS.)	3615	3778	3634	3797	3709	3872	3716	3880	3740	3904	4137	4175	4263	4275	4282	4334	4375
LOAD CAPACITY (LBS.)	1285	1122	1766	1603	1891	1728	2334	2170	2460	2296	2263	2925	3237	3925	2318	3066	3825
VOLUME CAPACITY (FT.^{3})	58.4	74.3	58.4	74.3	58.4	74.3	58.4	74.3	58.4	74.3	74.3	74.3	74.3	74.3	74.3	74.3	74.3
LENGTH (IN.)	78.2	98.1	78.2	98.1	78.2	98.1	78.2	98.1	78.2	98.1	98.1	98.1	98.1	98.1	98.1	98.1	98.1
WIDTH (IN.)	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72
HEIGHT (IN.)	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5
PASSENGER CAPACITY	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
LOAD EFFICIENCY	0.355	0.297	0.486	0.422	0.510	0.446	0.628	0.559	0.658	0.588	0.547	0.701	0.759	0.918	0.541	0.707	0.874
VOLUME EFFICIENCY X 10^2	1.62	1.97	1.61	1.96	1.57	1.91	1.57	1.91	1.56	1.90	1.80	1.78	1.74	1.74	1.74	1.71	1.70
PASSENGER EFFICIENCY																	

NOTE: ALL MODELS WITH STANDARD EQUIPMENT EXCEPT AS NOTED

* NOT STANDARD EQUIPMENT

LOAD, VOLUME & PASSENGER CAPACITIES
LIGHT DUTY VEHICLES

MAKE CHEVROLET

YEAR 1978

TYPE	PICKUP		UTILITY	
	CONVENTIONAL CAB		WITH HARDTOP, DRIVER & PASSENGER* BUCKET SEATS	
			2 WHEEL DRIVE	4 WHEEL DRIVE
MODEL	LUV	EL CAMINO	C10	K10
GVWR (LBS.)	3950	4424	6050	6200
WHEELBASE (IN.)	102.4	117.1	106.5	106.5
CURB WEIGHT (LBS.)	2440	3174	4000	4351
LOAD CAPACITY (LBS.)	1510	1250	2050	1849
VOLUME CAPACITY (FT.^{3})	38.0	35.5	105.8	105.8
LENGTH (IN.)	73.0	79.5	66.4	66.4
WIDTH (IN.)	57.5	58.4	64.8	64.8
HEIGHT (IN.)	15.6	16.3	42.5	42.5
PASSENGER CAPACITY	2	3	1/5 ø	1/5 ø
LOAD EFFICIENCY	0.619	0.394	0.512	0.425
VOLUME EFFICIENCY X 10^2	1.56	1.19	2.65	2.43
+PASSENGER EFFICIENCY X 10^3			1.25	1.15

NOTE: ALL MODELS WITH STANDARD EQUIPMENT EXCEPT AS NOTED

\+ BASED ON MAXIMUM SEATING CAPACITY

* NOT STANDARD EQUIPMENT

ø FRONT PASSENGER SEAT & REAR BENCH SEAT REQ'D. - SP. EQUIP. REAR SEAT NOT INCLUDED IN LOAD & VOLUME CAPACITY CALCULATIONS.

LOAD, VOLUME & PASSENGER CAPACITIES
LIGHT DUTY VEHICLES

MAKE CHEVROLET

YEAR 1978

TYPE	VAN									
	FORWARD CONTROL - UNITIZED BODY									
MODEL	G-10								G-20	
GVWR	4900		5400		5600		6000		6400	6600
WHEELBASE	110	125	110	125	110	125	110	125	110	125
CURB WEIGHT (LBS.)	3666	3814	3709	3857	3726	3874	3721	3869	3679	3820
LOAD CAPACITY (LBS.)	1234.	1086	1691	1543	1874	1726	2279	2131	2721	2780
VOLUME CAPACITY (FT.^{3})	207.8	260.8	207.8	260.8	207.8	260.8	207.8	260.8	207.8	260.8
LENGTH (IN.)	94.2	118.2	94.2	118.2	94.2	118.2	94.2	118.2	94.2	118.2
WIDTH (IN.)	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0
HEIGHT (IN.)	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7
PASSENGER CAPACITY	2*	2*	2*	2*	2*	2*	2*	2*	2*	2*
LOAD EFFICIENCY	0.337	0.285	0.456	0.400	0.503	0.446	0.612	0.551	0.740	0.728
VOLUME EFFICIENCY X 10^2	5.67	6.82	5.59	6.74	5.56	6.71	5.57	6.72	5.63	6.81
PASSENGER EFFICIENCY										

NOTE: ALL MODELS WITH STANDARD EQUIPMENT EXCEPT AS NOTED

* NOT STANDARD EQUIPMENT
REQUIRES PASSENGER SEAT - Sp. Equip.

LOAD, VOLUME & PASSENGER CAPACITIES
LIGHT DUTY VEHICLES

MAKE CHEVROLET

YEAR 1978

TYPE	VAN										
	FORWARD CONTROL--UNITIZED BODY										
MODEL	G-30										
GVWR	6400	6900	7100	7700	8100		6600	7100	7400	7900	8400
WHEELBASE	110	110	110	110	110		125	125	125	125	125
CURB WEIGHT (LBS.)	3914	3926	3954	4079	4197		4062	4074	4102	4227	4345
LOAD CAPACITY (LBS.)	2486	2974	3146	3621	3903		2538	3026	3298	3673	4055
VOLUME CAPACITY (FT.^{3})	207.8	207.8	207.8	207.8	207.8		260.8	260.8	260.8	260.8	260.8
LENGTH (IN.)	94.2	94.2	94.2	94.2	94.2		118.2	118.2	118.2	118.2	118.2
WIDTH (IN.)	71.0	71.0	71.0	71.0	71.0		71.0	71.0	71.0	71.0	71.0
HEIGHT (IN.)	53.7	53.7	53.7	53.7	53.7		53.7	53.7	53.7	53.7	53.7
PASSENGER CAPACITY	2*	2*	2*	2*	2*		2*	2*	2*	2*	2*
LOAD EFFICIENCY	0.635	0.757	0.796	0.888	0.930		0.625	0.743	0.804	0.869	0.933
VOLUME EFFICIENCY X 10^2	5.30	5.28	5.24	5.08	4.94		6.40	6.38	6.34	6.15	5.99
PASSENGER EFFICIENCY											

NOTE: ALL MODELS WITH STANDARD EQUIPMENT EXCEPT AS NOTED

* NOT STANDARD EQUIPMENT
REQUIRES PASSENGER SEAT
Sp. Equip.

LOAD, VOLUME & PASSENGER CAPACITIES
LIGHT DUTY VEHICLES

MAKE CHEVROLET

YEAR 1978

TYPE	VAN - WAGON									
	FORWARD CONTROL - UNITIZED BODY									
MODEL	G10				G20		G30			
GVWR	5600		6000		6400	6600	6600	7100	7400	8150
WHEELBASE	110	125	110	125	110	125	125	125	125	125
CURB WEIGHT (LBS.)	3970	4146	3983	4159	3963	4128	4375	4487	4515	4636
LOAD CAPACITY (LBS.)	1630	1454	2017	1841	2437	2472	2225.	2613.	2885	3514
VOLUME CAPACITY (FT.^{3})	129.6	182.6	129.6	182.6	129.6	182.6	182.6	182.6	182.6	182.6
LENGTH (IN.)	60.2	84.2	60.2	84.2	60.2	84.2	84.2	84.2	84.2	84.2
WIDTH (IN.)	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0
HEIGHT (IN.)	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7
PASSENGER CAPACITY	5	5	5	5	5/8*	5/8*	5/8*	5/8*/12*	5/8*/12*	5/8*/12*
LOAD EFFICIENCY	0.411	0.351	0.506	0.443	0.615	0.599	0.509	0.582	0.639	0.758
VOLUME EFFICIENCY X 10^2	3.26	4.40	3.26	4.39	3.27	4.42	4.17	4.07	4.04	3.94
+ PASSENGER EFFICIENCY X 10^3	1.26	1.21	1.25	1.20	2.02	1.94	1.83	2.67	2.66	2.59

NOTE: ALL MODELS WITH STANDARD EQUIPMENT EXCEPT AS NOTED

+ BASED ON MAXIMUM SEATING CAPACTIY

* NOT STANDARD EQUIPMENT
REQUIRES SECOND AND THIRD BENCH SEATS
SPECIAL EQUIPMENT
ADDED SEATS NOT INCLUDED IN
LOAD AND VOLUME CAPACITY
CALCULATIONS

LOAD, VOLUME & PASSENGER CAPACITIES
LIGHT DUTY VEHICLES

MAKE DODGE

YEAR 1978

TYPE	PICKUP										UTILITY	
	CONVENTIONAL CAB - SWEPTLINE										WITH HARDTOP*, DRIVER & PASSENGER BUCKET SEATS	
											2 WHEEL DRIVE	4 WHEEL DRIVE
MODEL	D-100				D-150		D-200				AD-100	AW 100
GVWR (LBS.)	5000		5500		6100		6200	6900	7500	8100	6100	6100
WHEELBASE (IN.)	115	131	115	131	115	131	131	131	131	131	106	106
CURB WEIGHT (LBS.)	3465	3580	3480	3595	3520	3635	3805	3840	3880	3945	3810	4285
LOAD CAPACITY (LBS.)	1535	1420	2020	1905	2580	2465	2395	3060	3620	4155	2290	1815
VOLUME CAPACITY (FT.^{3})	61.1	76.6	61.1	76.6	61.1	76.6	76.6	76.6	76.6	76.6	111.8	111.8
LENGTH (IN.)	78.0	98.0	78.0	98.0	78.0	98.0	98.0	98.0	98.0	98.0	72.0	72.0
WIDTH (IN.)	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	64.2	64.2
HEIGHT (IN.)	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	41.8	41.8
PASSENGER CAPACITY	3	3	3	3	3	3	3	3	3	3	2/6ø	2/6ø
LOAD EFFICIENCY	0.443	0.397	0.580	0.530	0.733	0.678	0.629	0.797	0.933	1.053	0.601	0.424
VOLUME EFFICIENCY X 10^2	1.78	2.14	1.76	2.13	1.75	2.11	2.01	1.99	1.97	1.94	2.93	2.61
+ PASSENGER EFFICIENCY X 10^3											1.57	1.40

NOTE: ALL MODELS WITH STANDARD EQUIPMENT EXCEPT AS NOTED

+ BASED ON MAXIMUM SEATING CAPACITY

* NOT STANDARD EQUIPMENT

ø REAR SEAT & FRONT BENCH SEAT REQUIRED - SPECIAL EQUIPMENT REAR SEAT NOT INCLUDED IN LOAD & VOLUME CAPACITY CALCULATIONS

LOAD, VOLUME & PASSENGER CAPACITIES
LIGHT DUTY VEHICLES

MAKE DODGE

YEAR 1978

TYPE	VAN													
	FORWARD CONTROL - UNITIZED BODY													
MODEL	B100						B200							
GVWR (LBS.)	4600		4800		5500		6000		6100			6400		
WHEELBASE (IN.)	109	127	109	127	109	127	109	127	109	127	127 Maxi	109	127	127 Maxi
CURB WEIGHT (LBS.)	3440	3560	3455	3575	3495	3620	3515	3635	3525	3645	3820	3615	3735	3955
LOAD CAPACITY (LBS.)	1160	1040	1345	1225	2005	1880	2485	2365	2575	2455	2280	2785	2665	2445
VOLUME CAPACITY (FT.^{3})	201.5	240.5	201.5	240.5	201.5	240.5	201.5	240.5	201.5	240.5	296.9	201.5	240.5	296.9
LENGTH (IN.)	92.9	110.9	92.9	110.9	92.9	110.9	92.9	110.9	92.9	110.9	136.9	92.9	110.9	136.9
WIDTH (IN.)	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2
HEIGHT (IN.)	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2
PASSENGER CAPACITY	2*	2*	2*	2*	2*	2*	2*	2*	2*	2*	2*	2*	2*	2*
LOAD EFFICIENCY	0.337	0.292	0.389	0.343	0.574	0.519	0.707	0.651	0.730	0.674	0.597	0.770	0.714	0.618
VOLUME EFFICIENCY X 10^2	5.86	6.76	5.83	6.73	5.77	6.64	5.73	6.62	5.72	6.60	7.77	5.57	6.44	7.51
PASSENGER EFFICIENCY														

NOTE: ALL MODELS WITH STANDARD EQUIPMENT EXCEPT AS NOTED

* NOT STANDARD EQUIPMENT
REQUIRES PASSENGER SEAT
SPECIAL EQUIPMENT

LOAD, VOLUME & PASSENGER CAPACITIES
LIGHT DUTY VEHICLES

MAKE DODGE

YEAR 1978

TYPE	VAN										
	FORWARD CONTROL - UNITIZED BODY										
MODEL	B300										
GVWR (LBS.)	6400			7000			7700			8200	
WHEELBASE (IN.)	109	127	127 Maxi	109	127	127 Maxi	109	127	127 Maxi	127	127 Maxi
CURB WEIGHT (LBS.)	3715	3825	3980	3725	3835	4005	3750	3880	4060	3895	4075
LOAD CAPACITY (LBS.)	2685	2575	2420	3275	3165	2995	3950	3820	3640	4305	4125
VOLUME CAPACITY ($FT.^3$)	201.5	240.5	296.9	201.5	240.5	296.9	201.5	240.5	296.9	240.5	296.9
LENGTH (IN.)	92.9	110.9	136.9	92.9	110.9	136.9	92.9	110.9	136.9	110.9	136.9
WIDTH (IN.)	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2
HEIGHT (IN.)	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2
PASSENGER CAPACITY	2*	2*	2*	2*	2*	2*	2*	2*	2*	2*	2*
LOAD EFFICIENCY	0.723	0.673	0.608	0.879	0.825	0.748	1.05	0.985	0.897	1.11	1.01
VOLUME EFFICIENCY X 10^2	5.42	6.29	7.46	5.41	6.27	7.41	5.37	6.20	7.31	6.17	7.29
PASSENGER EFFICIENCY											

NOTE: ALL MODELS WITH STANDARD EQUIPMENT EXCEPT AS NOTED

* NOT STANDARD EQUIPMENT
REQUIRES PASSENGER SEAT-
SPECIAL EQUIPMENT

LOAD, VOLUME & PASSENGER CAPACITIES
LIGHT DUTY VEHICLES

MAKE DODGE

YEAR 1978

TYPE	VAN WAGON												
	FORWARD CONTROL - UNITIZED BODY												
MODEL	B100						B200						
GVWR (LBS.)	4800		5200		5500		6000		6100			6400	
WHEELBASE (IN.)	109	127	109	127	109	127	109	127	109	127	127 Maxi	127	127 Maxi
CURB WEIGHT (LBS.)	3645	3775	3670	3790	3705	3825	3725	3845	3735	3855	4065	4045	4255
LOAD CAPACITY (LBS.)	1155	1025	1530	1410	1795	1675	2275	2155	2365	2245	2035	2355	2145
VOLUME CAPACITY (FT.^{3})	120.4	159.4	120.4	159.4	120.4	159.4	120.4	159.4	120.4	159.4	215.8	159.4	215.8
LENGTH (IN.)	55.5	73.5	55.5	73.5	55.5	73.5	55.5	73.5	55.5	73.5	91.5	73.5	91.5
WIDTH (IN.)	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2
HEIGHT (IN.)	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2	53.2
PASSENGER CAPACITY	5	5	5	5	5	5	5/8*	5/8*	5/8*	5/8*	5/8*	5/8*	5/8*
LOAD EFFICIENCY	0.317	0.272	0.417	0.372	0.484	0.438	0.611	0.560	0.633	0.582	0.501	0.582	0.504
VOLUME EFFICIENCY X 10^2	3.30	4.22	3.28	4.21	3.25	4.17	3.23	4.15	3.22	4.13	5.31	3.94	5.07
+ PASSENGER EFFICIENCY	1.37	1.32	1.36	1.32	1.35	1.31	2.15	2.08	2.14	2.07	1.97	1.98	1.88

NOTE: ALL MODELS WITH STANDARD EQUIPMENT EXCEPT AS NOTED
+BASED ON MAXIMUM SEATING CAPACITY

* NOT STANDARD EQUIPMENT
REQUIRES SECOND BENCH SEAT
SPECIAL EQUIPMENT
ADDED SEAT NOT INCLUDED
IN LOAD AND VOLUME CAPACITY
CALCULATIONS

LOAD, VOLUME & PASSENGER CAPACITIES
LIGHT DUTY VEHICLES

MAKE: DODGE

YEAR: 1978

TYPE	VAN WAGON					
	FORWARD CONTROL - UNITIZED BODY					
MODEL	B300					
GVWR (LBS.)	6700		7100		7700	
WHEELBASE (IN.)	127	127 Maxi	127	127 Maxi	127	127 Maxi
CURB WEIGHT (LBS.)	4175	4330	4175	4330	4215	4370
LOAD CAPACITY (LBS.)	2525	2370	2925	2770	3485	3330
VOLUME CAPACITY (FT.^{3})	159.4	215.8	159.4	215.8	159.4	215.8
LENGTH (IN.)	73.5	91.5	73.5	91.5	73.5	91.5
WIDTH (IN.)	70.2	70.2	70.2	70.2	70.2	70.2
HEIGHT (IN.)	53.2	53.2	53.2	53.2	53.2	53.2
PASSENGER CAPACITY	5/8*/12*	5/8*/ 12*/15*	5/8*/12*	5/8*/ 12*/15	5/8*/12*	5/8*/ 12*/15*
LOAD EFFICIENCY	0.605	0.547	0.701	0.640	0.827	0.762
VOLUME EFFICIENCY X 10^2	3.82	4.98	3.82	4.98	3.78	4.94
+ PASSENGER EFFICIENCY X 10^3	2.87	3.46	2.87	3.46	2.85	3.43

NOTE: ALL MODELS WITH STANDARD EQUIPMENT EXCEPT AS NOTED
+ BASED ON MAXIMUM SEATING CAPACITY

* NOT STANDARD EQUIPMENT
REQUIRES SECOND, THIRD & FOURTH BENCH SEATS - SP. EQUIP.
ADDED SEATS NOT INCLUDED IN LOAD & VOLUME CAPACITY CALCULATIONS

LOAD, VOLUME & PASSENGER CAPACITIES
LIGHT DUTY VEHICLES

MAKE FORD

YEAR 1978

TYPE	PICKUP															UTILITY	
	CONVENTIONAL CAB - STYLESIDE															WITH HARDTOP, DRIVER & PASS. BUCKET SEATS 4-WHEEL DRIVE	
MODEL	F100					F150		F250				F350	Ranchero 500	Courier		U-150	
GVWR	4800	4900	5200	5400	5600	6050	6150	6200	6800	7700	7900	8300	5255	3951	4011	6010	6550
WHEELBASE	133	117	133	117	133	133	133	133	133	133	133	140	118	106.9	112.8	104	104
CURB WEIGHT (LBS.)	3625	3560	3650	3605	3685	3695	3680	3815	3830	3940	4150	4410	4005	2551	2611	4642	4674
LOAD CAPACITY (LBS.)	1175	1340	1550	1795	1915	2355	2470	2385	2970	3760	3750	3890	1250	1400	1400	1368	1876
VOLUME CAPACITY ($FT.^3$)	73.6	61	73.6	61	73.6	73.6	73.6	73.6	73.6	73.6	73.6	65.1	38.2	38.4	44.33	97.0	97.0
LENGTH (IN.)	98.2	82	98.2	82	98.2	98.2	98.2	98.2	98.2	98.2	98.2	98.2	78.2	75.0	86.5	61.5	61.5
WIDTH (IN.)	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	65.0	53.4	61.4	61.4	63.5	63.5
HEIGHT (IN.)	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	16.7	16.1	16.1	43.1	43.1
PASSENGER CAPACITY	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2/6*	2/6*
LOAD EFFICIENCY	0.324	0.376	0.425	0.498	0.520	0.637	0.671	0.625	0.775	0.954	0.904	0.882	0.312	0.549	0.536	0.295	0.401
VOLUME EFFICIENCY X 10^2	2.03	1.71	2.02	1.69	2.00	1.99	2.00	1.93	1.92	1.87	1.77	1.48	0.96	1.51	1.70	2.09	2.07
+PASSENGER EFFICIENCY X 10^3																1.29	1.28

NOTE: ALL MODELS WITH STANDARD EQUIPMENT EXCEPT AS NOTED

+ BASED ON MAXIMUM SEATING CAPACITY

* NOT STANDARD EQUIPMENT
REQUIRES REAR SEAT AND FRONT BENCH SEAT-SPECIAL EQUIPMENT
REAR SEAT NOT INCLUDED IN LOAD AND VOLUME CAPACITY CALCULATION

LOAD, VOLUME & PASSENGER CAPACITIES
LIGHT DUTY VEHICLES

MAKE FORD

YEAR 1978

TYPE	VAN									
	SEMI-FORWARD CONTROL									
MODEL	E100				E150		E250			E350
GVWR	5150		5750		6100		6750	7550	8250	8550
WHEELBASE	124	138	124	138	124	138	138	138	138	138
CURB WEIGHT (LBS.)	3795	3975	3855	4045	3740	3930	4255	4330	4355	4415
LOAD CAPACITY (LBS.)	1355	1175	1895	1705	2360	2170	2495	3220	3895	4135
VOLUME CAPACITY (FT.^{3})	199.2	243.1	199.2	243.1	199.2	243.1	243.1	243.1	243.1	243.1
LENGTH (IN.)	93.0	113.0	93.0	113.0	93.0	113.0	113.0	113.0	113.0	113.0
WIDTH (IN.)	70.3	70.3	70.3	70.3	70.3	70.3	70.3	70.3	70.3	70.3
HEIGHT (IN.)	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0
PASSENGER CAPACITY	2*	2*	2*	2*	2*	2*	2*	2*	2*	2*
LOAD EFFICIENCY	0.357	0.296	0.492	0.422	0.631	0.552	0.586	0.744	0.894	0.937
VOLUME EFFICIENCY X 10^2	5.25	6.12	5.17	6.01	5.33	6.19	5.71	5.61	5.58	5.51
PASSENGER EFFICIENCY										

NOTE: ALL MODELS WITH STANDARD EQUIPMENT EXCEPT AS NOTED

* NOT STANDARD EQUIPMENT
REQUIRES PASSENGER SEAT
SP. EQUIPMENT

LOAD, VOLUME & PASSENGER CAPACITIES
LIGHT DUTY VEHICLES

MAKE FORD

YEAR 1978

TYPE	VAN-WAGON							
	SEMI-FORWARD CONTROL							
MODEL	E100		E150				E250	
GVWR	5500	6000	6200		6700		6800	7800
WHEELBASE	124	124	124	138	124	138	138	138
CURB WEIGHT (LBS.)	4086	4204	4154	4284	4267	4400	4570	4683
LOAD CAPACITY (LBS.)	1414	1796	2046	1916	2433	2300	2230	3117
VOLUME CAPACITY (FT.^{3})	123.2	123.2	123.2	167.1	123.2	167.1	167.1	167.1
LENGTH (IN.)	58.4	58.4	58.4	78.4	58.4	78.4	78.4	78.4
WIDTH (IN.)	70.3	70.3	70.3	70.3	70.3	70.3	70.3	70.3
HEIGHT (IN.)	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0
PASSENGER CAPACITY	5	5/8*	5/8*	5/8*	5/8*	5/8*	5/8*	5/8*/12*
LOAD EFFICIENCY	0.346	0.427	0.493	0.447	0.570	0.523	0.487	0.666
VOLUME EFFICIENCY X 10^2	3.02	2.93	2.97	3.90	2.89	3.80	3.66	3.57
+ PASSENGER EFFICIENCY X 10^3	1.22	1.90	1.93	1.87	1.88	1.82	1.75	2.56

NOTE: ALL MODELS WITH STANDARD EQUIPMENT EXCEPT AS NOTED
+ BASED ON MAXIMUM SEATING CAPACITY

* NOT STANDARD EQUIPMENT
REQUIRES SECOND & THIRD BENCH SEATS - SP. EQUIP.
ADDED SEATS NOT INCLUDED IN LOAD & VOLUME CAPACITY CALCULATIONS

LOAD, VOLUME & PASSENGER CAPACITIES
LIGHT DUTY VEHICLES

MAKE INTERNATIONAL

YEAR 1978

TYPE	UTILITY	
	WITH HARDTOP AND FRONT SEAT	
	2-WHEEL DRIVE	4-WHEEL DRIVE
MODEL	SCOUT	SCOUT
GVWR (LBS.)	6200	6200
WHEELBASE (IN.)	100	100
CURB WEIGHT (LBS.)	3625	3805
LOAD CAPACITY (LBS.)	2575	2395
VOLUME CAPACITY (FT.^{3})	82	82
LENGTH (IN.)	60.8	60.8
WIDTH (IN.)	54.8	54.8
HEIGHT (IN.)	41.9	41.9
PASSENGER CAPACITY	3/6*	3/6*
LOAD EFFICIENCY	0.710	0.629
VOLUME EFFICIENCY X 10^2	2.26	2.16
+ PASSENGER EFFICIENCY X 10^3	1.66	1.58

NOTE: ALL MODELS WITH STANDARD EQUIPMENT EXCEPT AS NOTED
+ BASED ON MAXIMUM SEATING CAPACITY

* NOT STANDARD EQUIPMENT

LOAD, VOLUME & PASSENGER CAPACITIES
LIGHT DUTY VEHICLES

MAKE CITROEN-FIAT

YEAR 1978

TYPE	PICKUP	VAN	
	FORWARD CONTROL - UNITIZED BODY	FORWARD CONTROL - UNITIZED BODY	
	FRONT WHEEL DRIVE	FRONT WHEEL DRIVE	
MODEL	FIAT 242115	FIAT 242115	
GVWR (LBS.)	6600	6886	
WHEELBASE (IN.)	126	126	
CURB WEIGHT (LBS.)	3300	3586	
LOAD CAPACITY (LBS.)	3300	3300	
VOLUME CAPACITY (FT.^{3})	127.1	328.4	
LENGTH (IN.)	118.3	118.3	
WIDTH (IN.)	70.5	70.5	
HEIGHT (IN.)	27.8	71.9	
PASSENGER CAPACITY	2	2/14 *	
LOAD EFFICIENCY	1.000	0.920	
VOLUME EFFICIENCY X 10^2	3.85	9.16	
+ PASSENGER EFFICIENCY X 10^3		3.94	

NOTE: ALL MODELS WITH STANDARD EQUIPMENT EXCEPT AS NOTED
+ BASED ON MAXIMUM SEATING CAPACITY

* NOT STANDARD EQUIPMENT
REQUIRES EXTRA SEATS - SPECIAL EQUIPMENT NOT INCLUDED IN LOAD AND VOLUME CAPACITY CALCULATIONS.

LOAD, VOLUME & PASSENGER CAPACITIES
LIGHT DUTY VEHICLES

MAKE NISSAN - DATSON

YEAR 1978

TYPE	UTILITY	VAN
EQUIPMENT	4-WHEEL DRIVE	CARAVAN HONEY
MODEL	G60	VBP 20
GVWR (LBS.)	5037	5555
WHEELBASE (IN.)	98.5	107.6
CURB WEIGHT (LBS.)	3785	2990
LOAD CAPACITY (LBS.)	1252	2565
VOLUME CAPACITY (FT.^{3})	64.5	200.4
LENGTH (IN.)	52.6	112.3
WIDTH (IN.)	43.7	59.7
HEIGHT (IN.)	48.5	51.8
PASSENGER CAPACITY	3/6*	3/6*
LOAD EFFICIENCY	0.551	0.858
VOLUME EFFICIENCY X 10^2	1.76	6.70
+ PASSENGER EFFICIENCY X 10^3	1.64	2.02

NOTE: ALL MODELS WITH STANDARD EQUIPMENT EXCEPT AS NOTED

+ BASED ON MAXIMUM SEATING CAPACITY

* NOT STANDARD EQUIPMENT
REQUIRES REAR BENCH SEAT - SPECIAL EQUIPMENT NOT INCLUDED IN LOAD AND VOLUME CAPACITY CALCULATIONS

LOAD, VOLUME & PASSENGER CAPACITIES
LIGHT DUTY VEHICLES

MAKE VOLKSWAGEN

YEAR 1978

TYPE	VAN					
	FORWARD CONTROL					
EQUIPMENT						
MODEL	LT28		LT31		LT35	
GVWR (LBS.)	6160		6776		7700	
WHEELBASE (IN.)	98.4		98.4		98.4	
CURB WEIGHT (LBS.)	3410		3476		3608	
LOAD CAPACITY (LBS.)	2750		3300		4092	
VOLUME CAPACITY (FT.^{3})	277		277		277	
LENGTH (IN.)	121.6		121.6		121.6	
WIDTH (IN.)	71.3		71.3		71.3	
HEIGHT (IN.)	57.5		57.5		57.5	
PASSENGER CAPACITY	2		2		2	
LOAD EFFICIENCY	0.806		0.949		1.134	
VOLUME EFFICIENCY X 10^2	8.12		7.97		7.68	
PASSENGER EFFICIENCY X 10^3						

NOTE: ALL MODELS WITH STANDARD EQUIPMENT EXCEPT AS NOTED

* NOT STANDARD EQUIPMENT

APPENDIX C

PERFORMANCE CRITERIA SPECIFICATIONS

AND PERFORMANCE FACTORS

LIGHT DUTY VEHICLES

MAKE AMERICAN MOTORS

YEAR 1978

TYPE	PICKUP								UTILITY			
MODEL	J10 (4 Wheel Drive)		J20 (4 Wheel Drive)						CJ5 & CJ7 (4 Wheel Drive)			
GVWR	6200		6800			8400			3750		4150	
EQUIPMENT	STD.	33%	STD.	33%	33%	STD.	33%	33%	STD.	33%	STD.	33%
ENGINE TYPE	I6	V8	V8	V8	V8	V8	V8	V8	I6	V8	I6	V8
DISPLACEMENT	258	360	360	360	360	360	360	360	232	304	232	304
HORSE POWER	118	170	170	170	170	170	170	170	95	146	95	146
TORQUE	206	285	285	285	285	285	285	285	172	232	172	232
TRANS. TYPE	3M	3A	3M	3A	4M	3M	3A	4M	3M	3A	3M	3A
RATIO MAX.	2.99	5.95	2.99	5.95	6.32	2.99	5.95	6.32	2.99	5.95	2.99	5.95
AXLE RATIO	4.09	3.54	3.73	3.73	3.73	3.73	3.73	3.73	3.54	3.54	3.54	3.54
TIRE SIZE	H	H	O	O	O	O	O	O	H	H	H	H
REV/MILE	734	734	734	734	734	734	734	734	734	734	734	734
N/V RATIO	50.03	43.31	45.63	45.63	45.63	45.63	45.63	45.63	43.31	43.31	43.31	43.31
PF_A	0.019	0.027	0.025	0.025	0.025	0.020	0.020	0.020	0.025	0.039	0.023	0.035
PF_T	1.143	1.836	1.315	1.764	2.780	1.065	1.428	2.250	1.366	2.471	1.234	2.233
PF_S	1.249	1.509	1.449	1.449	1.449	1.173	1.173	1.173	1.608	2.107	1.453	1.904

PERFORMANCE CRITERIA SPECIFICATIONS

AND PERFORMANCE FACTORS

LIGHT DUTY VEHICLES

MAKE CHEVROLET

YEAR 1978

TYPE	PICKUP																		
MODEL	C10						C10/44					C20							
GVWR	4900		5400		5600		6050		6200			6400		7100		7400		8200	
EQUIPMENT	STD	33%	STD	33%	STD	33%	STD	33%	STD	33%		STD	33%	STD	33%	STD	33%	STD	33%
ENGINE TYPE	I6	V8	I6	V8	I6	V8	I6	V8	I6	V8		I6	V8	I6	V8	I6	V8	I6	V8
DISPLACEMENT	250	305	250	305	250	305	250	350	250	350		292	350	292	350	292	350	292	350
HORSE POWER	115	145	115	145	115	145	115	165	115	165		120	165	120	165	120	165	120	165
TORQUE	195	245	195	245	195	245	175	255	175	255		215	255	215	255	215	255	215	255
TRANS. TYPE	3M	3A	3M	3A	3M	3A	4M	3A	4M	3A		3M	3A	4M	3A	4M	3A	4M	3A
RATIO MAX.	2.85	5.29	2.85	5.29	2.85	5.29	6.56	5.29	6.56	5.29		2.85	5.29	6.56	5.29	6.56	5.29	6.56	5.29
AXLE RATIO	3.07	2.76	3.07	2.76	3.07	2.76	3.40	3.07	3.40	3.07		4.10	4.10	3.73	4.10	3.73	4.10	4.10	4.10
TIRE SIZE	G	G	H	H	L	L	L	L	M	M		R	R	S	S	U	U	U	U
REV/MILE	739	739	734	734	715	715	715	715	715	715		712	712	712	712	682	682	682	682
N/Y RATIO	37.81	33.99	37.56	33.76	36.58	32.89	40.52	36.58	40.52	36.58		48.65	48.65	44.26	48.65	42.40	46.60	46.60	46.60
PF_A	0.023	0.030	0.021	0.027	0.021	0.026	0.017	0.027	0.016	0.027		0.019	0.026	0.017	0.023	0.016	0.022	0.015	0.020
PF_T	0.986	1.394	0.889	1.256	0.835	1.180	1.768	1.264	1.726	1.233		1.071	1.589	2.022	1.432	1.859	1.317	1.843	1.188
PF_S	1.157	1.270	1.043	1.144	0.980	1.075	1.005	1.270	0.980	1.239		1.332	1.596	1.092	1.439	1.004	1.322	0.996	1.193

PERFORMANCE CRITERIA SPECIFICATIONS

AND PERFORMANCE FACTORS

LIGHT DUTY VEHICLES

MAKE CHEVROLET

YEAR 1978

TYPE	PICKUP									UTILITY			
MODEL	LUV		EL CAMINO			C10 (Diesel)				BLAZER			
GVWR	3950		4674			5300	5600	6050	6200	6050 (2 Wheel Drive)		6200 (4 Wheel Drive)	
EQUIPMENT	STD.	OPT.	STD.	OPT.	OPT.	STD.	STD.	STD.	STD.	STD	33%	STD	33%
ENGINE TYPE	I4	I4	V6	V8	V8	V8	V8	V8	V8	I6	V8	I6	V8
DISPLACEMENT	110.8	110.8	200	305	350	350	350	350	350	250	305	250	350
HORSE POWER	80	80	95	145	160	120	120	120	120	115	140	115	165
TORQUE	95	95	160	245	260	220	220	220	220	175	235	175	255
TRANS. TYPE	4M	3A	3M	3A	3A	3A	3A	3A	3A	3M	3A	4M	3A
RATIO MAX.	3.51	6.08	3.50	5.04	5.04	5.29	5.29	5.29	5.29	2.85	5.29	6.56	5.29
AXLE RATIO	4.10	4.10	2.73	2.41	2.41	2.76	2.76	2.76	2.76	4.11	3.07	3.73	3.07
TIRE SIZE	B	B	D	D	D	G	L	L	M	H	H	H	H
REV/MILE	795	795	800	800	800	739	715	715	715	734	734	734	734
N/V RATIO	54.33	54.33	36.40	32.13	32.13	33.99	32.89	32.89	32.89	50.28	37.56	45.63	37.56
PF_A	0.020	0.020	0.020	0.031	0.034	0.023	0.021	0.020	0.019	0.019	0.023	0.018	0.027
PF_T	1.055	1.231	1.003	1.316	1.396	1.157	1.059	0.981	0.957	0.953	1.196	1.943	1.267
PF_S	0.914	0.914	0.935	1.258	1.444	1.347	1.233	1.142	1.114	1.247	1.136	1.104	1.272

PERFORMANCE CRITERIA SPECIFICATIONS
AND PERFORMANCE FACTORS
LIGHT DUTY VEHICLES

MAKE CHEVROLET
YEAR 1978

TYPE	PICKUP				VAN							
MODEL	C30				G10							
GVWR	9000		10,000		4900		5400		5600		6000	
EQUIPMENT	STD	33%	STD	33%	STD	33%	STD	33%	STD	33%	STD	33%
ENGINE TYPE	I6	V8	V8	V8	I6	V8	I6	V8	I6	V8	I6	V8
DISPLACEMENT	292	350	350	350	250	305	250	305	250	305	250	305
HORSE POWER	120	165	165	165	115	145	115	145	115	145	115	145
TORQUE	215	255	255	255	195	245	195	245	195	245	195	245
TRANS. TYPE	4M	3A	4M	3A	3M	3A	3M	3A	3M	3A	3M	3A
RATIO MAX.	6.56	5.29	6.56	5.29	2.85	5.29	2.85	5.29	2.85	5.29	2.85	5.29
AXLE RATIO	4.10	4.10	4.10	4.10	3.08	2.73	3.08	2.73	3.08	2.73	3.42	2.73
TIRE SIZE	V	V	R	R	F	F	F	F	G	G	H	H
REV/MILE	682	682	712	712	762	762	762	762	739	739	734	734
N/V RATIO	46.60	42.40	48.65	48.65	39.12	34.67	39.12	34.67	37.94	33.62	41.84	33.40
PF_A	0.013	0.018	0.017	0.017	0.023	0.030	0.021	0.027	0.021	0.026	0.019	0.024
PF_T	1.680	0.985	1.872	1.017	1.020	1.421	0.926	1.290	0.866	1.206	0.891	1.118
PF_S	0.907	0.989	1.022	1.022	1.198	1.295	1.087	1.175	1.016	1.099	1.046	1.019

MAKE CHEVROLET

YEAR 1978

PERFORMANCE CRITERIA SPECIFICATIONS AND PERFORMANCE FACTORS LIGHT DUTY VEHICLES

TYPE	VAN														
MODEL	G20					G30									
GVWR	6400		6600			6900		7100		7700		8100		8400	
EQUIPMENT	STD	33%	STD	33%		STD	33%	STD	33%	STD	33%	STD	33%	STD	33%
ENGINE TYPE	I6	V8	I6	V8		I6	V8	I6	V8	I6	V8	V8	V8	V8	V8
DISPLACEMENT	292	350	292	350		292	350	292	350	292	350	350	350	350	350
HORSE POWER	120	165	120	165		120	165	120	165	120	165	165	165	165	165
TORQUE	215	255	215	255		215	255	215	255	215	255	255	255	255	255
TRANS. TYPE	3M	3A	3M	3A		3M	3A	3M	3A	3M	3A	3M	3A	3M	3A
RATIO MAX.	2.85	5.29	2.85	5.29		2.85	5.29	2.85	5.29	2.85	5.29	2.85	5.29	2.85	5.29
AXLE RATIO	3.40	2.76	3.40	2.76		4.09	3.21	4.09	3.21	4.09	3.75	4.09	3.75	4.09	3.75
TIRE SIZE	K	K	K	K		N	N	R	R	S	S	S	S	T	T
REV/MILE	727	727	727	727		712	712	712	712	712	712	712	712	712	712
N/V RATIO	41.20	33.44	41.20	33.44		48.53	38.09	48.53	38.09	48.53	44.50	48.53	44.50	48.53	44.50
PF_A	0.019	0.026	0.018	0.025		0.017	0.024	0.017	0.023	0.016	0.021	0.020	0.020	0.020	0.020
PF_T	0.907	1.092	0.880	1.059		0.991	1.154	0.963	1.122	0.888	1.208	1.001	1.149	0.966	1.108
PF_S	1.128	1.097	1.094	1.064		1.232	1.159	1.198	1.127	1.104	1.214	1.258	1.154	1.213	1.112

MAKE DODGE

YEAR 1978

PERFORMANCE CRITERIA SPECIFICATIONS AND PERFORMANCE FACTORS LIGHT DUTY VEHICLES

TYPE	PICKUP														
MODEL	D100						D150			D200					
GVWR	5000			5500			6100			6200			6900		
EQUIPMENT	STD.	33%	33%	STD.	33%	33%	STD.	33%	33%	STD.	33%	33%	STD.	33%	33%
ENGINE TYPE	I6	I6	V8	I6	I6	V8	I6	I6	V8	I6	V8	V8	I6	V8	V8
DISPLACEMENT	225	225	318	225	225	318	225	225	318	225	318	360	225	318	360
HORSE POWER	115	115	145	115	115	145	115	115	150	115	150	175	115	150	175
TORQUE	175	175	250	175	175	250	175	175	230	175	230	275	175	230	275
TRANS. TYPE	3M	3A	3A	3M	3A	3A	3M	3A	3A	3M	3A	3A	4M	3A	3A
RATIO MAX.	2.99	4.66	4.66	2.99	4.66	4.66	2.99	4.66	4.66	2.99	4.66	4.66	4.56	4.66	4.66
AXLE RATIO	3.55	3.55	3.20	3.55	3.55	3.20	3.55	3.55	3.20	4.10	4.10	4.10	4.10	4.10	4.10
TIRE SIZE	G	G	G	H	H	H	H	H	H	O	O	O	P	P	P
REV/MILE	739	739	739	734	734	734	734	734	734	734	734	734	734	734	734
N/V RATIO	43.73	43.73	39.41	43.43	43.43	39.15	43.43	43.43	39.15	50.16	50.16	50.16	50.16	50.16	50.16
PF_A	0.023	0.023	0.029	0.021	0.021	0.026	0.019	0.019	0.025	0.019	0.024	0.028	0.017	0.022	0.025
PF_T	1.053	1.106	1.423	0.950	0.998	1.285	0.857	0.900	1.066	0.974	1.344	1.607	1.334	1.208	1.444
PF_S	1.181	1.181	1.504	1.066	1.066	1.358	0.961	0.961	1.225	1.092	1.544	1.747	0.981	1.387	1.570

PERFORMANCE CRITERIA SPECIFICATIONS

AND PERFORMANCE FACTORS

LIGHT DUTY VEHICLES

MAKE DODGE

YEAR 1978

TYPE	PICKUP														
MODEL	D200										D300				
GVWR	7500			8100			9000				10,000				
EQUIPMENT	STD.	33%	33%	STD.	33%	33%	STD.	33%	33%		STD.	33%	33%	33%	33%
ENGINE TYPE	16	V8	V8	16	V8	V8	16	V8	V8		16	V8	V8	V8	V8
DISPLACEMENT	225	318	360	225	318	360	225	318	360		225	318	360	318	360
HORSE POWER	115	150	175	115	150	175	115	150	175		115	150	175	150	175
TORQUE	175	230	275	175	230	275	175	230	275		175	230	275	230	275
TRANS. TYPE	4M	3A	3A	4M	3A	3A	4M	3A	3A		4M	4M	4M	3A	3A
RATIO MAX.	4.56	4.66	4.66	4.56	4.66	4.66	4.56	4.66	4.66		4.56	4.56	4.56	4.66	4.66
AXLE RATIO	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10		4.10	4.10	4.10	4.10	4.10
TIRE SIZE	T	T	T	U	U	U	V	V	V		O	O	O	O	O
REV/MILE	712	712	712	682	682	682	682	682	682		734	734	734	734	734
N/V RATIO	48.65	48.65	48.65	46.60	46.60	46.60	46.60	46.60	46.60		50.16	50.16	50.16	50.16	50.16
PF_A	0.015	0.020	0.023	0.014	0.019	0.022	0.013	0.017	0.019		0.012	0.015	0.018	0.015	0.018
PF_T	1.191	1.078	1.288	1.056	0.956	1.143	0.950	0.860	1.028		0.921	1.210	1.447	0.833	0.996
PF_S	0.876	1.238	1.401	0.777	1.098	1.243	0.699	0.988	1.118		0.677	0.957	1.083	0.957	1.083

PERFORMANCE CRITERIA SPECIFICATIONS

AND PERFORMANCE FACTORS

LIGHT DUTY VEHICLES

MAKE DODGE

YEAR 1978

TYPE	PICKUP											UTILITY					
MODEL	0150 (Diesel)		D200 (Diesel)									A0100 (2 Wheel Drive)			AW100 (4 Wheel Drive)		
GVWR	6100		6200		6900		7500		8100			6100			6100		
EQUIPMENT	STD.	33%	STD.	33%	STD.	33%	STD.	33%	STD.	33%		STD.	33%	33%	STD.	33%	33%
ENGINE TYPE	I6	I6	I6	I6	I6	I6	I6	I6	I6	I6		I6	V8	V8	I6	V8	V8
DISPLACEMENT	243	243	243	243	243	243	243	243	243	243		225	318	360	225	318	360
HORSE POWER	100	100	100	100	100	100	100	100	100	100		115	150	175	115	150	175
TORQUE	165	165	165	165	165	165	165	165	165	165		175	230	275	175	230	275
TRANS. TYPE	4M	3A	4M	3A	4M	3A	4M	3A	4M	3A		3M	3A	3A	3M	3A	3A
RATIO MAX.	6.68	4.66	6.68	4.66	6.68	4.66	6.68	4.66	6.68	4.66		2.99	4.66	4.66	2.99	4.66	4.66
AXLE RATIO	3.55	3.55	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10		3.55	3.20	3.20	3.55	3.55	3.55
TIRE SIZE	J	J	O	O	P	P	T	T	U	U		H	H	H	H	H	H
REV/MILE	734	734	734	734	734	734	712	712	682	682		734	734	734	734	734	734
N/V RATIO	43.43	43.43	50.16	50.16	50.16	50.16	48.65	48.65	46.60	46.60		43.43	39.15	39.15	43.43	43.43	43.43
PF_A	0.016	0.016	0.016	0.016	0.014	0.014	0.013	0.013	0.012	0.012		0.019	0.025	0.029	0.019	0.025	0.029
PF_T	1.805	0.849	2.051	0.964	1.843	0.866	1.644	0.773	1.458	0.686		0.857	1.066	1.275	0.857	1.183	1.414
PF_S	1.730	1.730	1.966	1.966	1.767	1.767	1.576	1.576	1.398	1.398		0.961	1.225	1.386	0.961	1.358	1.538

PERFORMANCE CRITERIA SPECIFICATIONS

AND PERFORMANCE FACTORS

LIGHT DUTY VEHICLES

MAKE DODGE

YEAR 1978

TYPE	VAN															
MODEL	B100						B200				B300					
GVWR	4600		4800		5500		6100		6400		7000		7700		0200	
EQUIPMENT	STD.	33%	STD.	33%	STD.	33%	STD.	33%	STD.	33%	STD.	33%	STD.	33%	STD.	33%
ENGINE TYPE	I6	V8	I6	V8	I6	V8	I6	V8	I6	V8	I6	V8	I6	V8	I6	V8
DISPLACEMENT	225	318	225	318	225	318	225	318	225	318	225	318	225	318	225	318
HORSE POWER	115	145	115	145	115	145	115	150	115	150	115	150	115	150	115	150
TORQUE	175	250	175	250	175	250	175	230	175	230	175	230	175	230	175	230
TRANS. TYPE	3M	3A	3M	3A	3M	3A	3M	3A	3M	3A	3A	3A	3A	3A	3A	3A
RATIO MAX.	2.99	4.66	2.99	4.66	2.99	4.66	2.99	4.66	2.99	4.66	4.66	4.66	4.66	4.66	4.66	4.66
AXLE RATIO	3.50	3.20	3.50	3.20	3.50	3.20	3.50	3.20	3.50	3.20	4.10	4.10	4.10	4.10	4.10	4.10
TIRE SIZE	E	E	E	E	G	G	H	H	M	M	O	O	P	P	T	T
REV/MILE	778	778	778	778	739	739	734	734	715	715	734	734	734	734	712	712
N/V RATIO	45.38	41.49	45.38	41.49	43.11	39.41	42.82	39.15	41.71	38.13	50.16	50.16	50.16	50.16	48.65	48.65
PF_A	0.025	0.032	0.024	0.030	0.021	0.026	0.019	0.025	0.018	0.023	0.016	0.021	0.015	0.019	0.014	0.018
PF_T	1.187	1.629	1.138	1.561	0.943	1.294	0.845	1.066	0.784	0.990	0.906	1.190	0.823	1.082	0.750	0.986
PF_S	1.332	1.721	1.276	1.649	1.058	1.367	0.948	1.225	0.880	1.137	0.967	1.367	0.879	1.243	0.801	1.132

PERFORMANCE CRITERIA SPECIFICATIONS

AND PERFORMANCE FACTORS

LIGHT DUTY VEHICLES

MAKE FORD

YEAR 1978

TYPE	PICKUP														
MODEL	F100														
GVWR	4800			4900			5200			5400			5600		
EQUIPMENT	STD	33%	33%	STD	33%	33%	STD	33%	33%	STD	33%	33%	STD	33%	33%
ENGINE TYPE	I6	V8	V8	I6	V8	V8	I6	V8	V8	I6	V8	V8	I6	V8	V8
DISPLACEMENT	300	302	351	300	302	351	300	302	351	300	302	351	300	302	351
HORSE POWER	120	136	163	120	136	163	120	136	163	120	136	163	120	136	163
TORQUE	249	245	284	249	245	284	249	245	284	249	245	284	249	245	284
TRANS. TYPE	3M	3A	3A	3M	3A	3A	3M	3A	3A	3M	3A	3A	3M	3A	3A
RATIO MAX.	2.99	4.60	4.60	2.99	4.60	4.60	2.99	4.60	4.60	2.99	4.60	4.60	2.99	4.60	4.60
AXLE RATIO	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75
TIRE SIZE	F	F	F	F	F	F	G	G	G	H	H	H	H	H	H
REV/MILE	762	762	762	762	762	762	739	739	739	734	734	734	734	734	734
N/V RATIO	34.93	34.93	34.93	34.93	34.93	34.93	33.87	33.87	33.87	33.64	33.64	33.64	33.64	33.64	33.64
PF_A	0.025	0.028	0.034	0.024	0.028	0.033	0.023	0.026	0.031	0.022	0.025	0.030	0.021	0.024	0.029
PF_T	1.246	1.271	1.474	1.221	1.245	1.444	1.115	1.140	1.319	1.067	1.088	1.261	1.029	1.049	1.216
PF_S	1.310	1.319	1.533	1.283	1.292	1.502	1.172	1.180	1.372	1.121	1.129	1.312	1.081	1.089	1.265

PERFORMANCE CRITERIA SPECIFICATIONS

AND PERFORMANCE FACTORS

LIGHT DUTY VEHICLES

MAKE FORD

YEAR 1978

TYPE	PICKUP																	
MODEL	F150							F250									F350		
GVWR	6050			6150				6200		6800		7700		7900			8300	8900	9900
EQUIPMENT	STD	33%	33%	STD	33%	33%		STD	33%	STD	33%	STD	33%	STD	33%		STD	STD	STD
ENGINE TYPE	I6	V8	V8	I6	V8	V8		I6	V8	I6	V8	I6	V8	V8	V8		V8	V8	V8
DISPLACEMENT	300	302	351	300	302	351		300	351	300	351	300	351	351	351		351	351	351
HORSE POWER	114	142	163	114	142	163		114	163	114	163	114	163	163	163		163	163	163
TORQUE	220	234	267	220	234	267		220	267	220	267	220	267	267	267		267	267	267
TRANS. TYPE	3M	3A	3A	3M	3A	3A		4M	3A	4M	3A	4M	3A	4M	3A		4M	4M	4M
RATIO MAX.	2.99	4.60	4.60	2.99	4.60	4.60		6.32	4.60	6.32	4.60	6.32	4.60	6.32	4.60		6.32	6.32	6.32
AXLE RATIO	3.50	2.75	2.75	3.50	2.75	2.75		3.73	3.31	3.73	3.31	3.73	3.31	3.31	3.31		3.73	3.73	3.73
TIRE SIZE	L	L	L	M	M	M		O	O	P	P	T	T	T	T		T	V	W
REV/MILE	715	715	715	715	715	715		734	734	734	734	712	712	712	712		712	682	651
N/V RATIO	41.71	32.77	32.77	41.71	32.77	32.77		45.63	40.49	45.63	40.49	44.26	39.28	39.28	39.28		44.26	42.40	40.47
PF_A	0.019	0.023	0.027	0.019	0.023	0.026		0.018	0.026	0.017	0.024	0.015	0.021	0.021	0.021		0.020	0.018	0.016
PF_T	1.043	0.904	1.031	1.026	0.889	1.014		2.354	1.243	2.146	1.133	1.838	0.971	1.930	0.946		2.070	1.849	1.587
PF_S	1.241	0.981	1.141	1.220	0.965	1.122		1.325	1.375	1.208	1.254	1.035	1.074	1.047	1.047		1.123	1.003	0.861

PERFORMANCE CRITERIA SPECIFICATIONS

AND PERFORMANCE FACTORS

LIGHT DUTY VEHICLES

MAKE FORD

YEAR 1978

TYPE	PICKUP								UTILITY			
MODEL	COURIER					RANCHERO			BRONCO (4 WHEEL DRIVE)			
GVWR	3575		4075			5285			6010		6550	
EQUIPMENT	STD	OPT	STD	OPT		STD	OPT		STD	33%	STD	33%
ENGINE TYPE	I4	I4	I4	I4		V8	V8		V8	V8	V8	V8
DISPLACEMENT	109.8	140.3	109.8	140.3		302	351		351	351	351	351
HORSE POWER	67	77	67	77		134	144		163	163	163	163
TORQUE	92	102	92	102		248	277		267	267	267	267
TRANS. TYPE	4M	3A	4M	3A		3A	3A		4M	3A	4M	3A
RATIO MAX.	4.36	4.60	4.36	4.60		4.60	4.60		6.69	4.60	6.69	4.60
AXLE RATIO	3.64	3.64	3.64	3.64		2.75	2.50		3.50	3.50	3.50	3.50
TIRE SIZE	A	A	A	A		C	C		L	L	L	L
REV/MILE	836	836	836	836		762	762		715	715	715	715
N/V RATIO	50.72	50.72	50.72	50.72		34.93	31.75		41.71	41.71	41.71	41.71
PF_A	0.019	0.022	0.016	0.019		0.025	0.027		0.027	0.027	0.025	0.025
PF_T	1.309	1.032	1.148	0.905		1.169	1.187		2.851	1.321	2.616	1.212
PF_S	0.935	1.194	0.820	1.048		1.198	1.265		1.462	1.462	1.341	1.341

PERFORMANCE CRITERIA SPECIFICATIONS

AND PERFORMANCE FACTORS

LIGHT DUTY VEHICLES

MAKE FORD

YEAR 1978

TYPE	VAN																		
MODEL	E100				E150			E250							E350				
GVWR	5150		5750		6100			6750		7550		8250			8550		9500		9800
EQUIPMENT	STD	33%	STD	33%	STD	33%		STD	33%	STD	33%	STD	33%		STD	33%	STD	33%	STD
ENGINE TYPE	I6	V8	I6	V8	I6	V8		I6	V8	I6	V8	I6	V8		I6	V8	I6	V8	V8
DISPLACEMENT	300	351	300	351	300	351		300	351	300	351	300	351		300	351	300	351	460
HORSE POWER	123	141	123	141	123	147		123	147	123	147	123	147		123	147	123	147	237
TORQUE	258	286	258	286	229	276		229	276	229	276	229	276		229	276	229	276	365
TRANS. TYPE	3M	3A	3M	3A	3M	3A		3M	3A	3M	3A	3M	3A		3A	3A	3A	3A	3A
RATIO MAX.	2.99	4.60	2.99	4.60	2.99	4.60		2.99	4.60	2.99	4.60	2.99	4.60		4.60	4.60	4.60	4.60	4.60
AXLE RATIO	2.75	2.75	2.75	2.75	3.50	2.75		3.73	3.31	3.73	3.31	3.73	3.31		4.10	3.73	4.10	3.73	3.73
TIRE SIZE	F	F	H	H	L	L		O	O	S	S	T	T		U	U	V	V	V
REV/MILE	762	762	734	734	715	715		734	734	712	712	712	712		682	682	682	682	682
N/V RATIO	34.93	34.93	33.64	33.64	41.71	32.77		45.63	40.49	44.26	39.28	44.26	39.28		46.60	42.40	46.60	42.40	42.40
PF_A	0.024	0.027	0.021	0.025	0.021	0.024		0.018	0.022	0.016	0.019	0.015	0.018		0.014	0.017	0.013	0.015	0.024
PF_T	1.203	1.383	1.038	1.193	1.077	1.057		1.065	1.180	0.923	1.024	0.845	0.937		0.890	0.976	0.898	0.878	1.126
PF_S	1.221	1.428	1.053	1.232	1.231	1.131		1.217	1.263	1.055	1.096	0.966	1.003		0.981	1.044	0.883	0.940	1.194

PERFORMANCE CRITERIA SPECIFICATIONS

AND PERFORMANCE FACTORS

LIGHT DUTY VEHICLES

MAKE INTERNATIONAL

YEAR 1978

TYPE	UTILITY				
MODEL	SCOUT (2 Wheel Drive or 4 Wheel Drive)				
GVWR	6200			6200 (Diesel)	
EQUIPMENT	STD.	33%	33%	STD.	33%
ENGINE TYPE	I4	V8	V8	I4	I4
DISPLACEMENT	196	304	304	198	198
HORSE POWER	86	144	144	81	81
TORQUE	157	247	247	138	138
TRANS. TYPE	3M	3A	4M	4M	3A
RATIO MAX.	3.00	4.66	6.32	4.02	4.66
AXLE RATIO	4.09	4.09	4.09	3.73	3.73
TIRE SIZE	H	H	H	H	H
REV/MILE	734	734	734	734	734
N/V RATIO	50.03	50.03	50.03	45.63	45.63
PF_A	0.014	0.023	0.023	0.013	0.013
PF_T	0.874	1.440	2.897	0.939	0.734
PF_S	0.949	1.472	1.472	0.874	0.874

PERFORMANCE CRITERIA SPECIFICATIONS
AND PERFORMANCE FACTORS
LIGHT DUTY VEHICLES

MAKE CITROEN-FIAT

YEAR 1978

TYPE	VAN		PICKUP	
MODEL	242/15 (FRONT WHEEL DRIVE)		242/15 (FRONT WHEEL DRIVE)	
GVWR	6886		6600	
EQUIPMENT				
ENGINE TYPE	*14	14	*14	14
DISPLACEMENT	132.7	121.1	132.7	121.1
HORSE POWER	61	64.1	61	64.1
TORQUE	92.6	96.2	92.6	96.2
TRANS. TYPE	4M O.D.	4M O.D.	4M O.D.	4 O.D.
RATIO MAX.	3.25	3.25	3.25	3.25
AXLE RATIO	8.24	8.24	8.24	8.24
TIRE SIZE	x	x	x	x
REV/MILE	737	737	737	737
N/V RATIO	101.2	101.2	101.2	101.2
PF_A	0.009	0.009	0.009	0.010
PF_T	1.02	1.06	1.06	1.10
PF_S	1.17	1.07	1.22	1.11

* DIESEL

PERFORMANCE CRITERIA SPECIFICATIONS

AND PERFORMANCE FACTORS

LIGHT DUTY VEHICLES

MAKE NISSAN - DATSUN

YEAR 1978

TYPE	UTILITY	VAN
MODEL	G60 (4-WHEEL DRIVE)	VPE 20
GVWR	5037	5555
EQUIPMENT		
ENGINE TYPE	I6	I4
DISPLACEMENT	241.3	120.9
HORSE POWER	130	92
TORQUE	217	115.7
TRANS. TYPE	3M	4M
RATIO MAX.	2.90	4.22
AXLE RATIO	4.10	4.625
TIRE SIZE	DD	BB
REV/MILE	695	779
N/V RATIO	47.49	60.05
PF_A	0.026	0.017
PF_T	0.920	0.818
PF_S	1.211	0.782

PERFORMANCE CRITERIA SPECIFICATIONS

AND PERFORMANCE FACTORS

LIGHT DUTY VEHICLES

MAKE VOLKSWAGEN

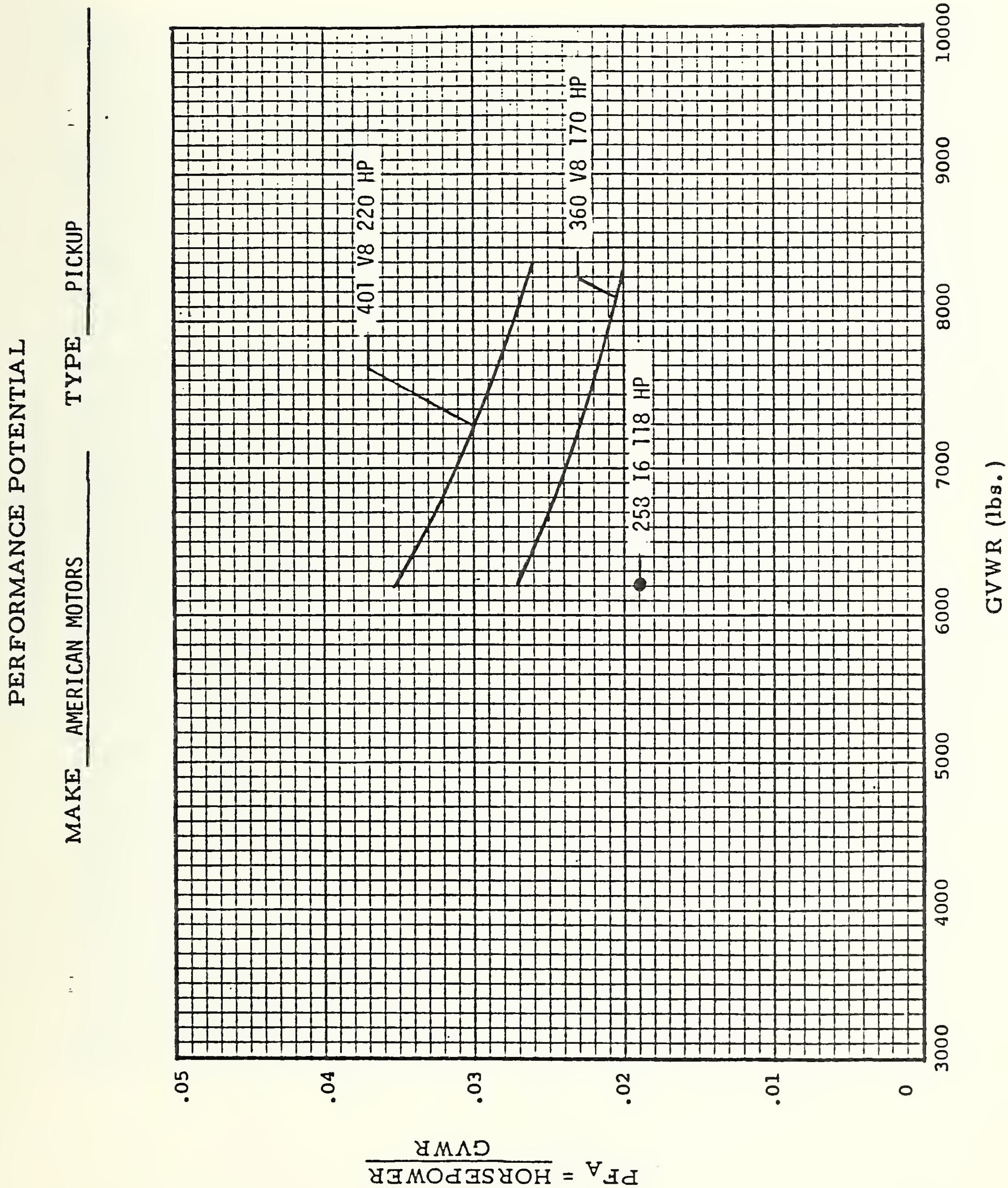
YEAR 1978

TYPE		VAN							
MODEL		LT 28			LT 31			LT 35	
GVWR		6160	6468		6776	7084		7700	8008
EQUIPMENT									
ENGINE TYPE		I4	I4*		I4	I4*		I4	I4*
DISPLACEMENT		121	165.3		121	165.3		121	165.3
HORSE POWER		74	62		74	62		74	62
TORQUE		108.5	110.7		108.5	110.7		108.5	110.7
TRANS. TYPE		4M	4M		4M	4M		4M	4M
RATIO MAX.		5.01	5.01		5.01	5.01		5.01	5.01
AXLE RATIO		4.88	4.88		4.88	4.88		4.88	4.88
TIRE SIZE		Y	Y		Z	Z		Y	Y
REV/MILE		812	812		792	792		812	812
N/V RATIO		66.04	66.04		64.4	64.4		66.04	66.04
PF_A		0.012	0.0096		0.011	0.0088		0.0096	0.0077
PF_T		1.340	1.302		1.188	1.160		1.072	1.052
PF_S		0.778	1.013		0.690	0.901		0.623	0.818

* DIESEL

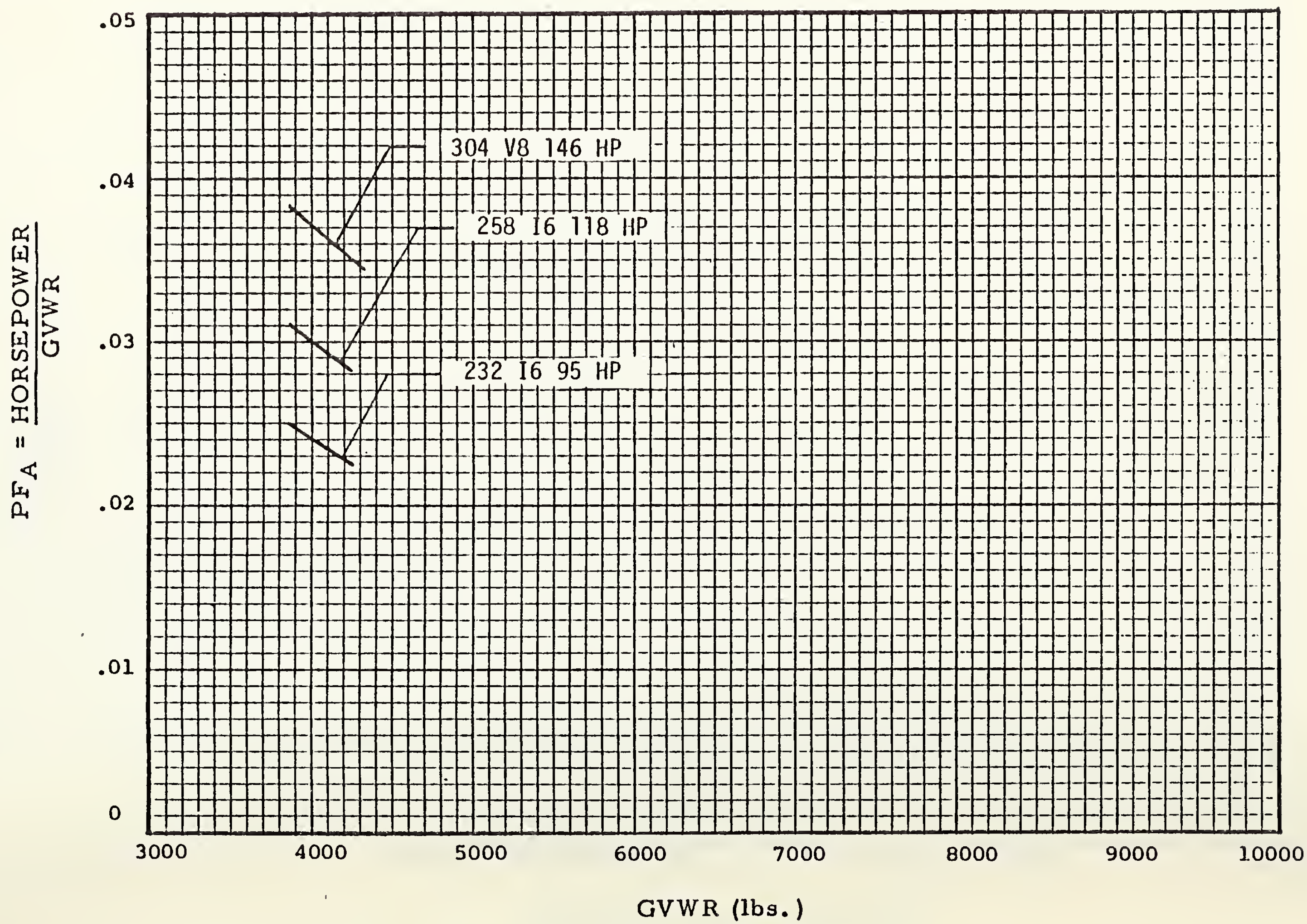
APPENDIX D

PERFORMANCE POTENTIAL



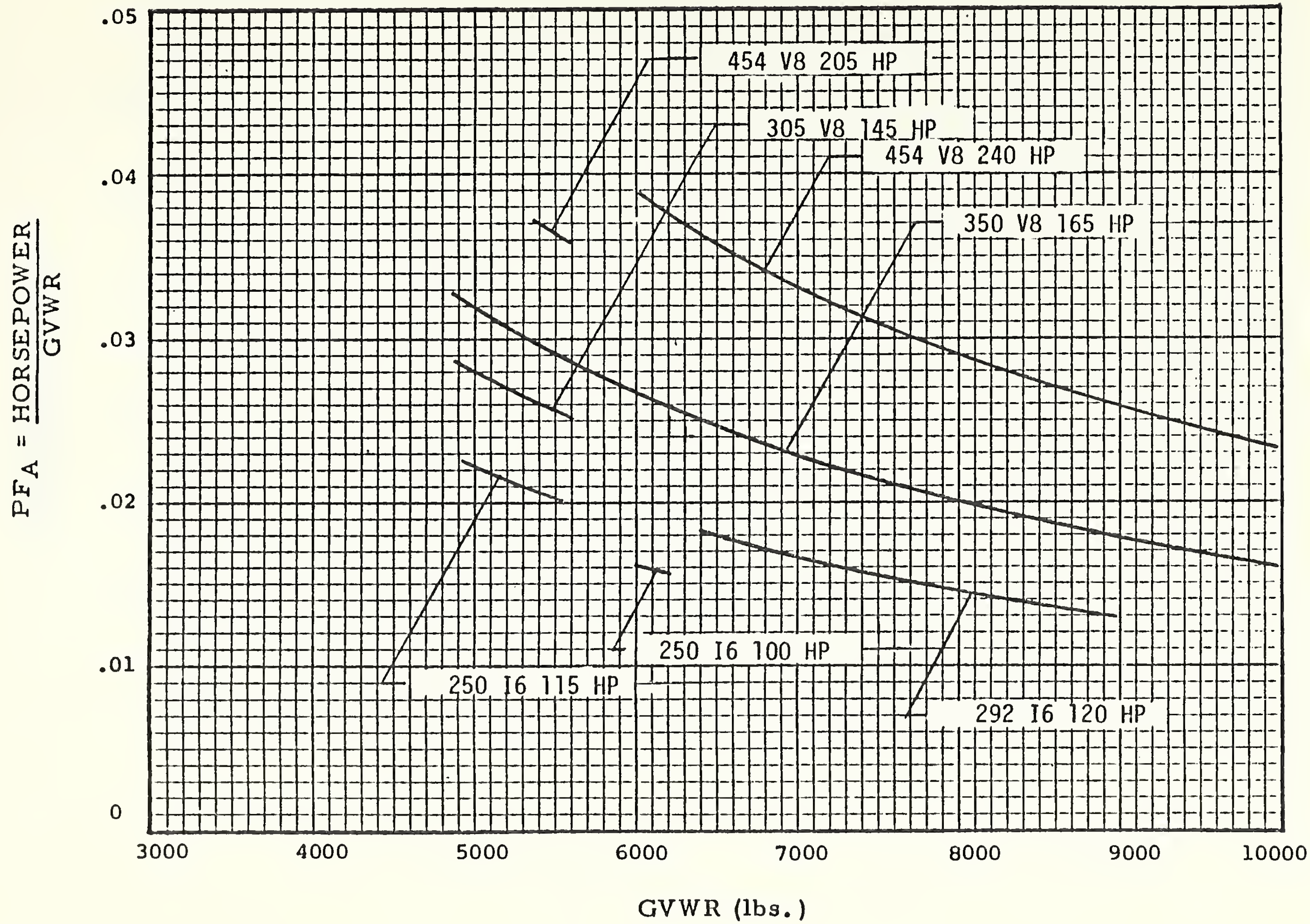
PERFORMANCE POTENTIAL

MAKE AMERICAN MOTORS TYPE UTILITY



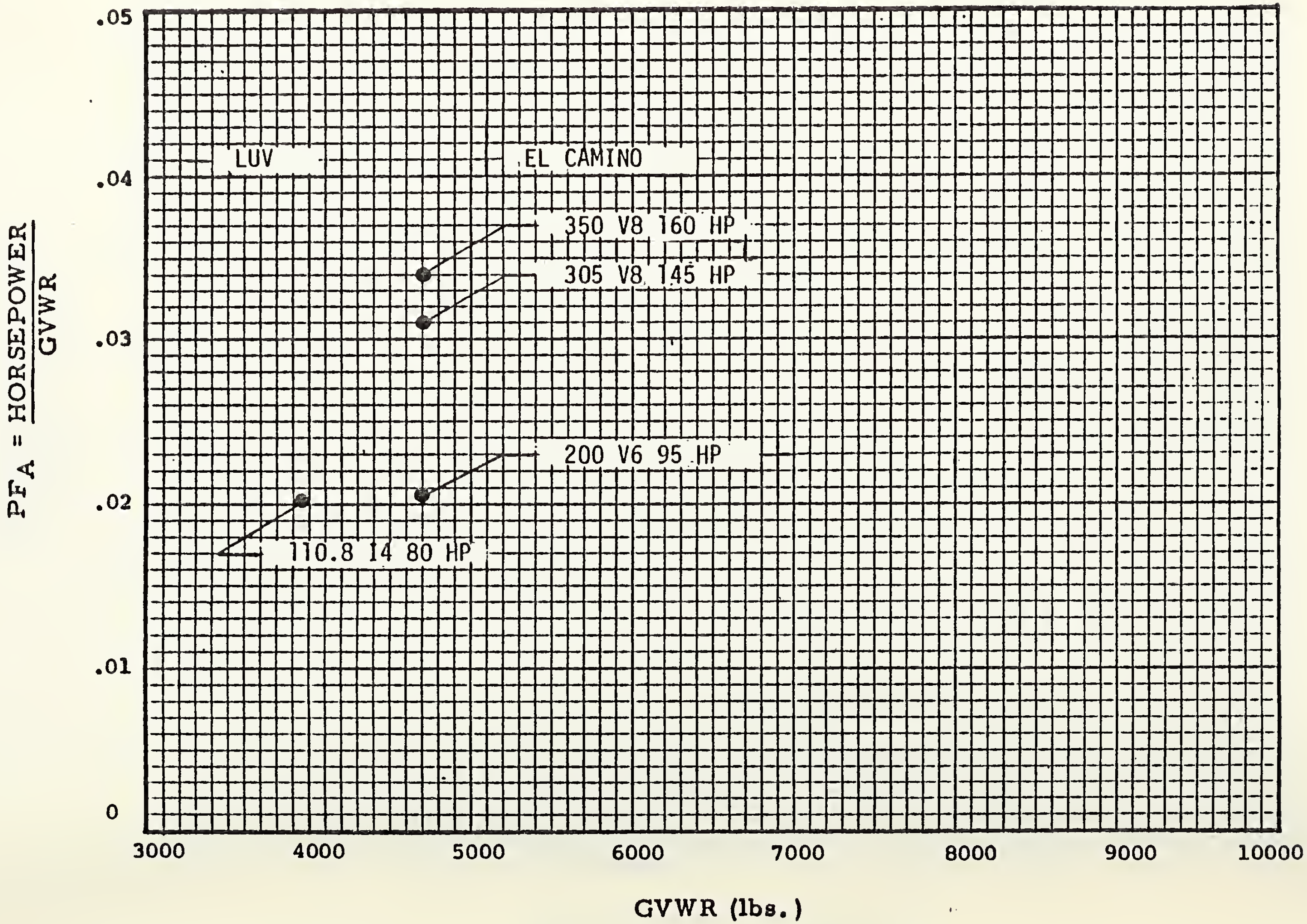
PERFORMANCE POTENTIAL

MAKE CHEVROLET TYPE PICKUP



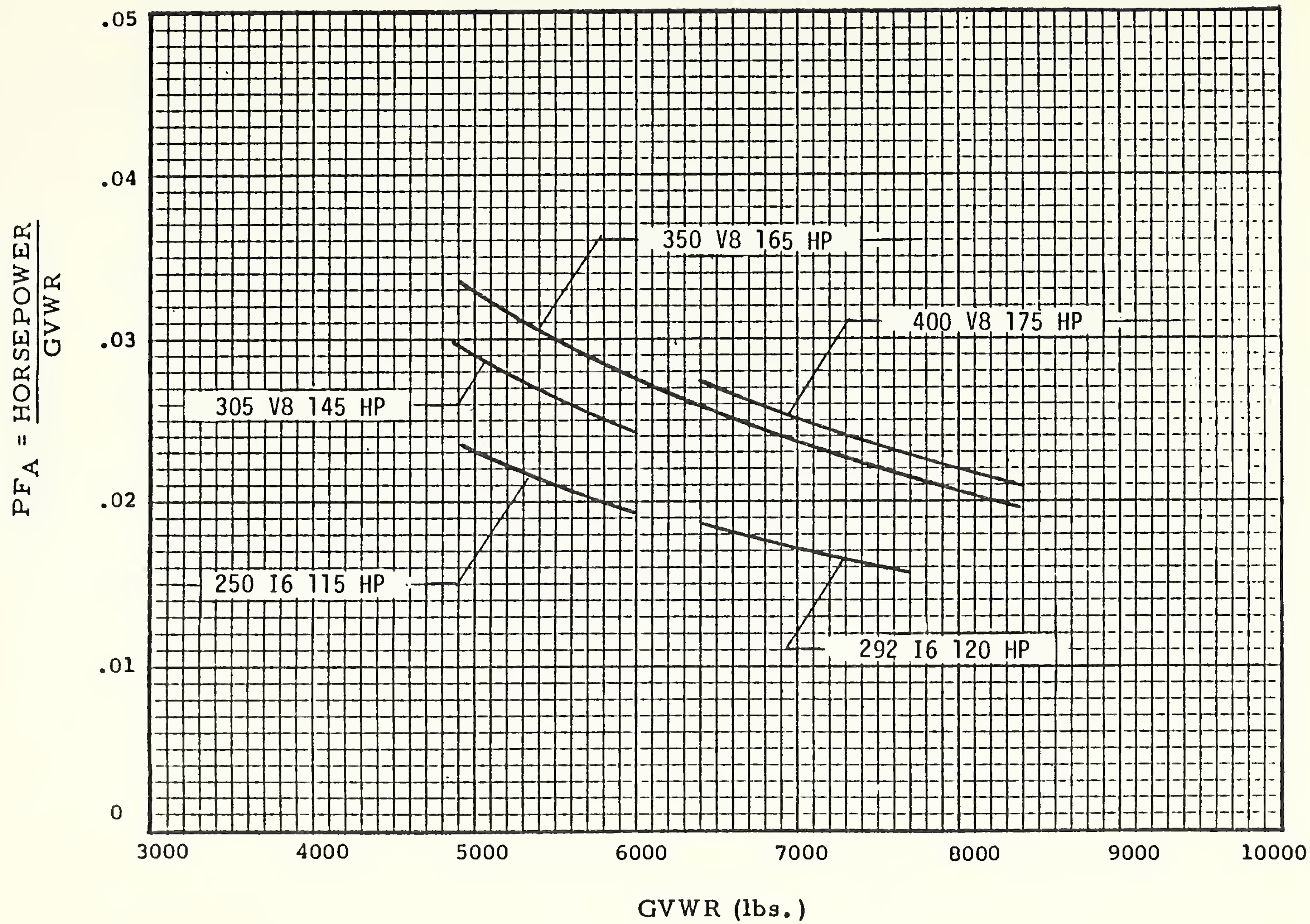
PERFORMANCE POTENTIAL

MAKE CHEVROLET TYPE PICKUP



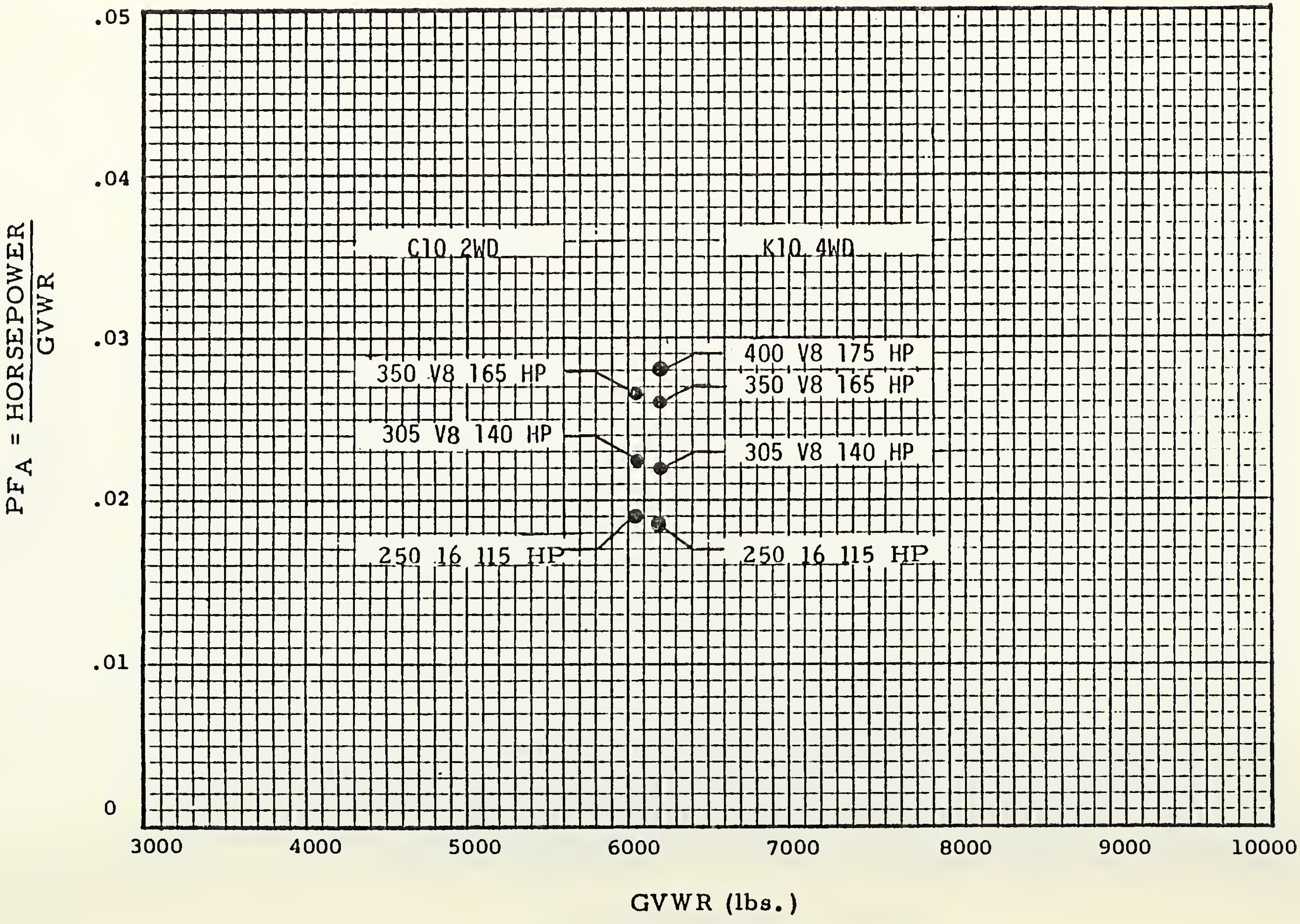
PERFORMANCE POTENTIAL

MAKE CHEVROLET TYPE VAN



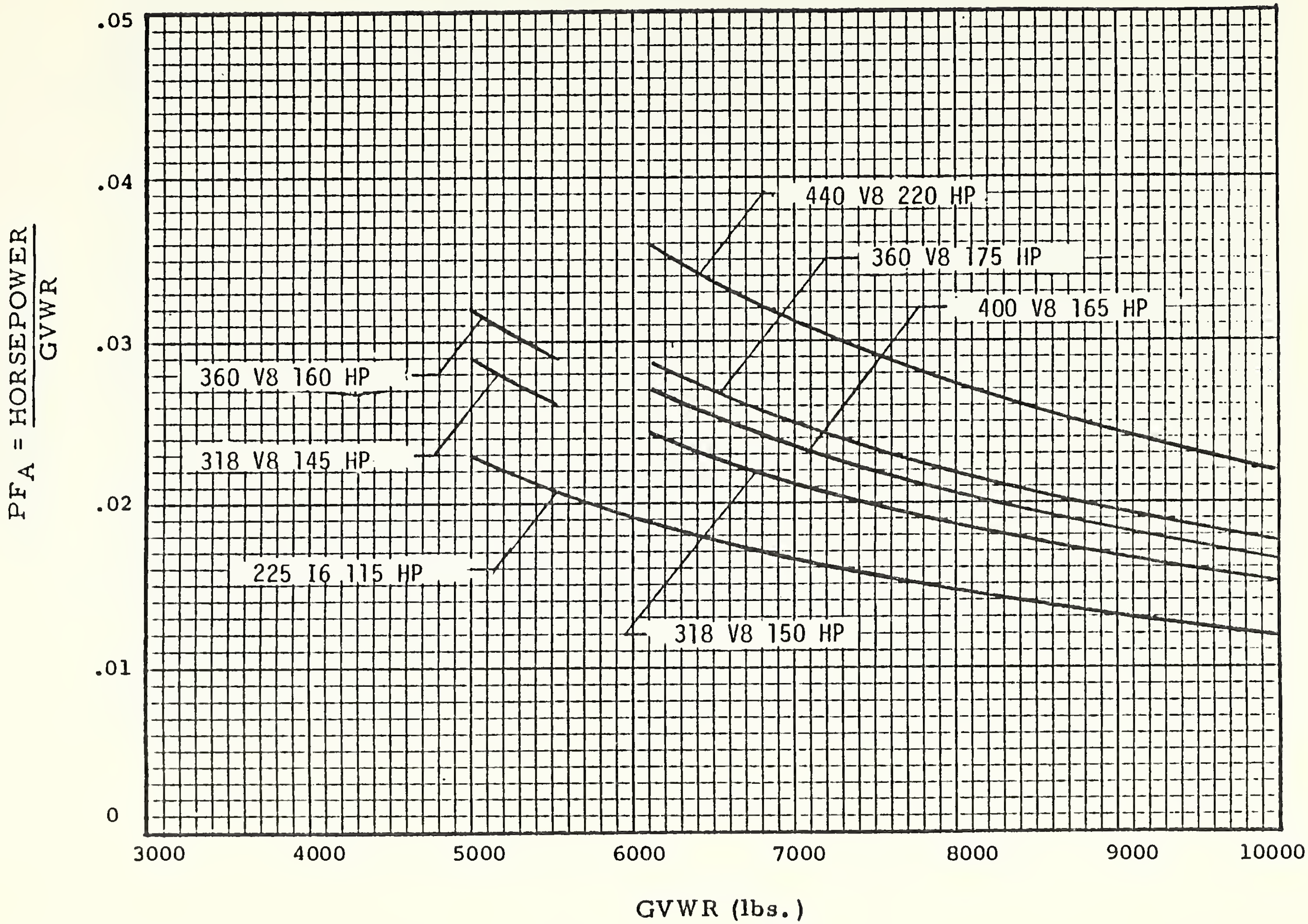
PERFORMANCE POTENTIAL

MAKE CHEVROLET TYPE UTILITY



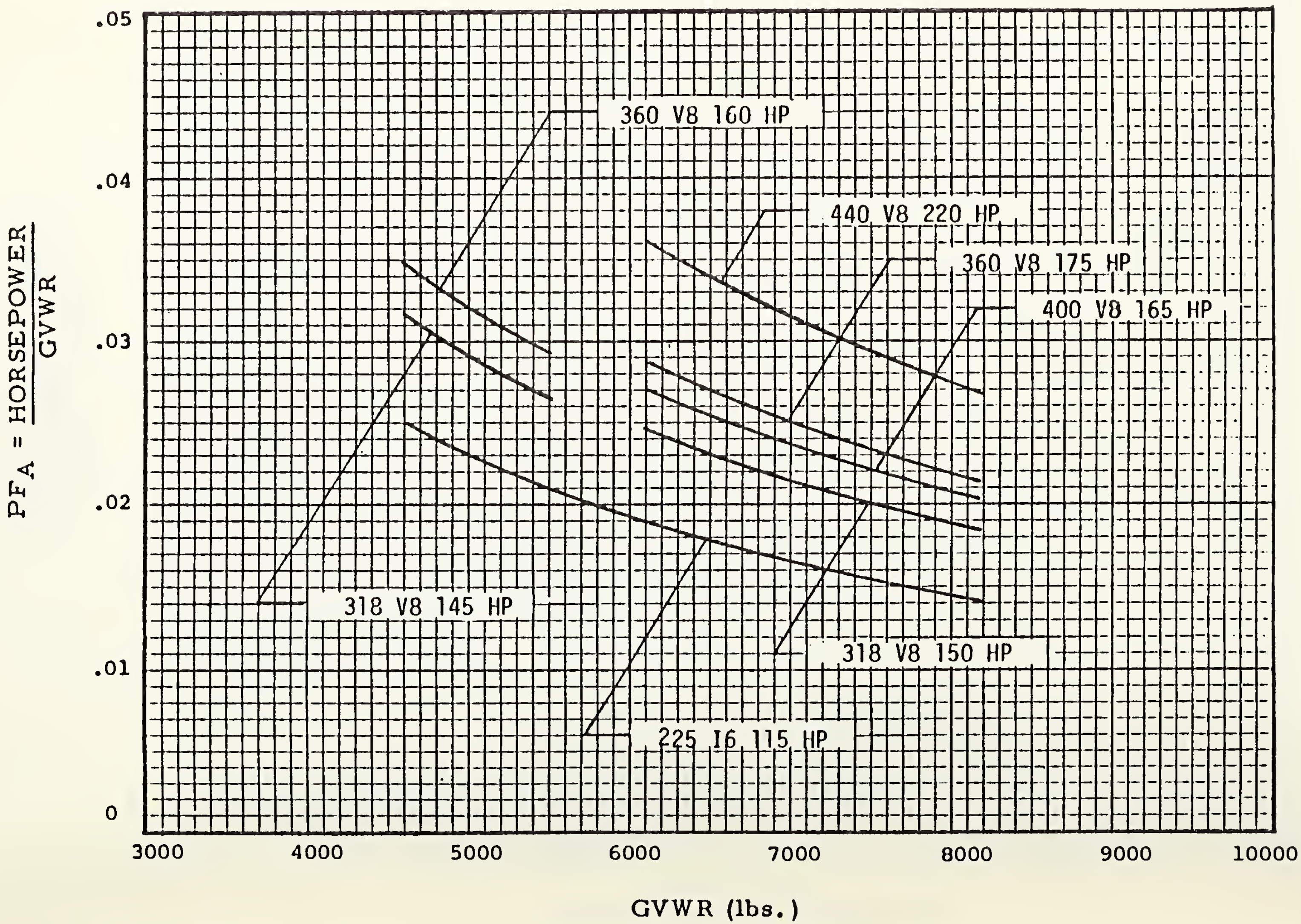
PERFORMANCE POTENTIAL

MAKE DODGE TYPE PICKUP



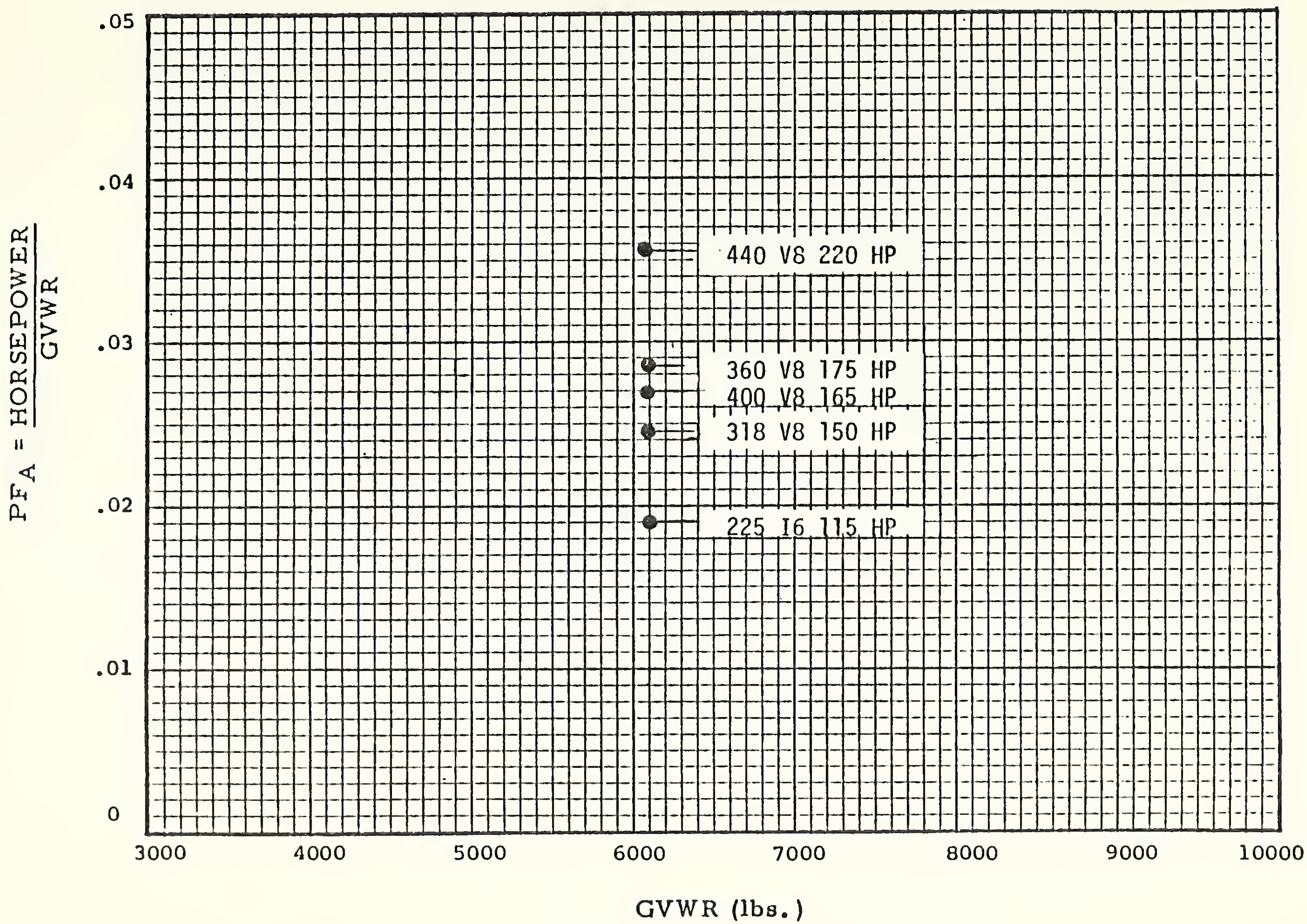
PERFORMANCE POTENTIAL

MAKE DODGE TYPE VAN



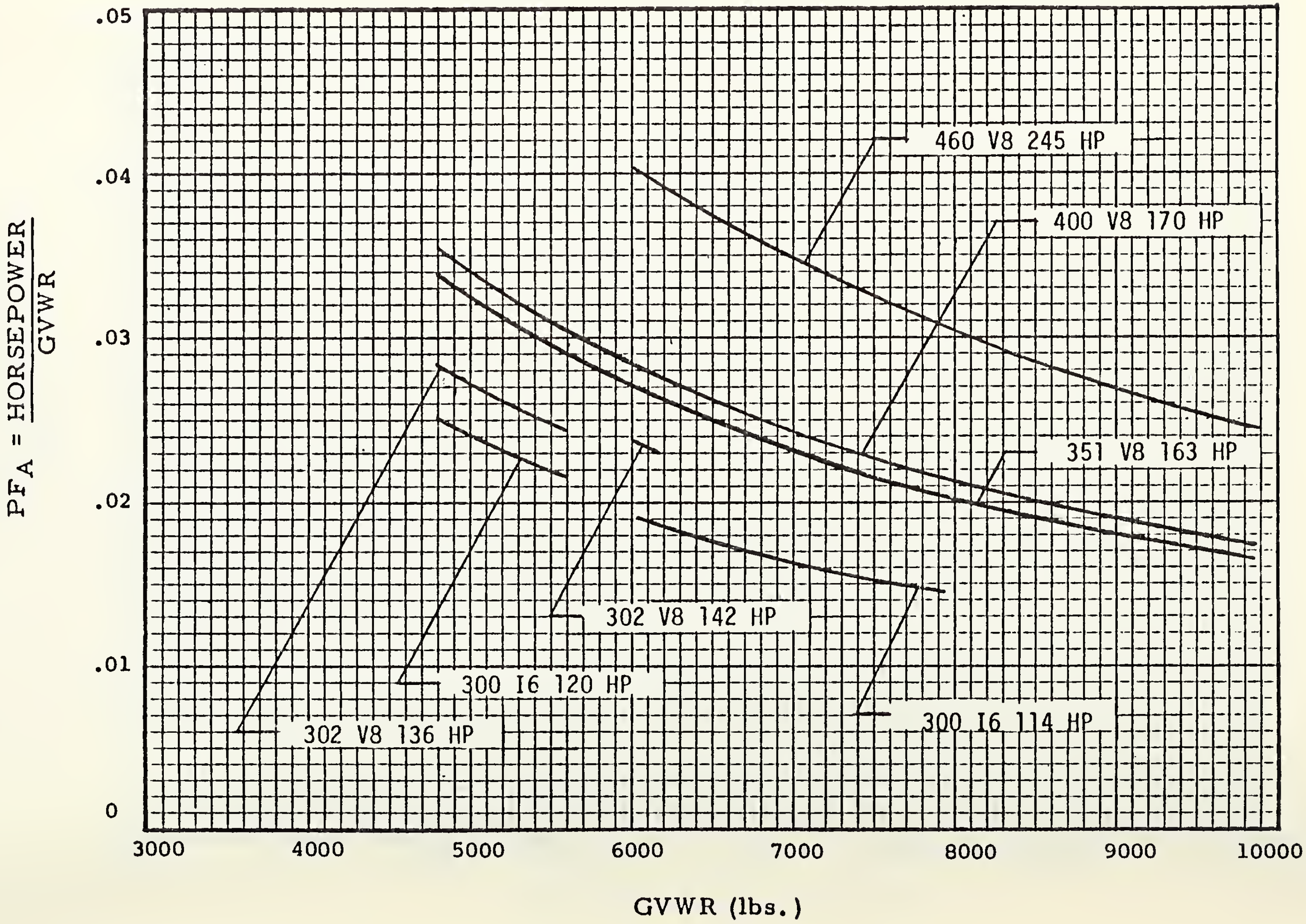
PERFORMANCE POTENTIAL

MAKE DODGE TYPE UTILITY



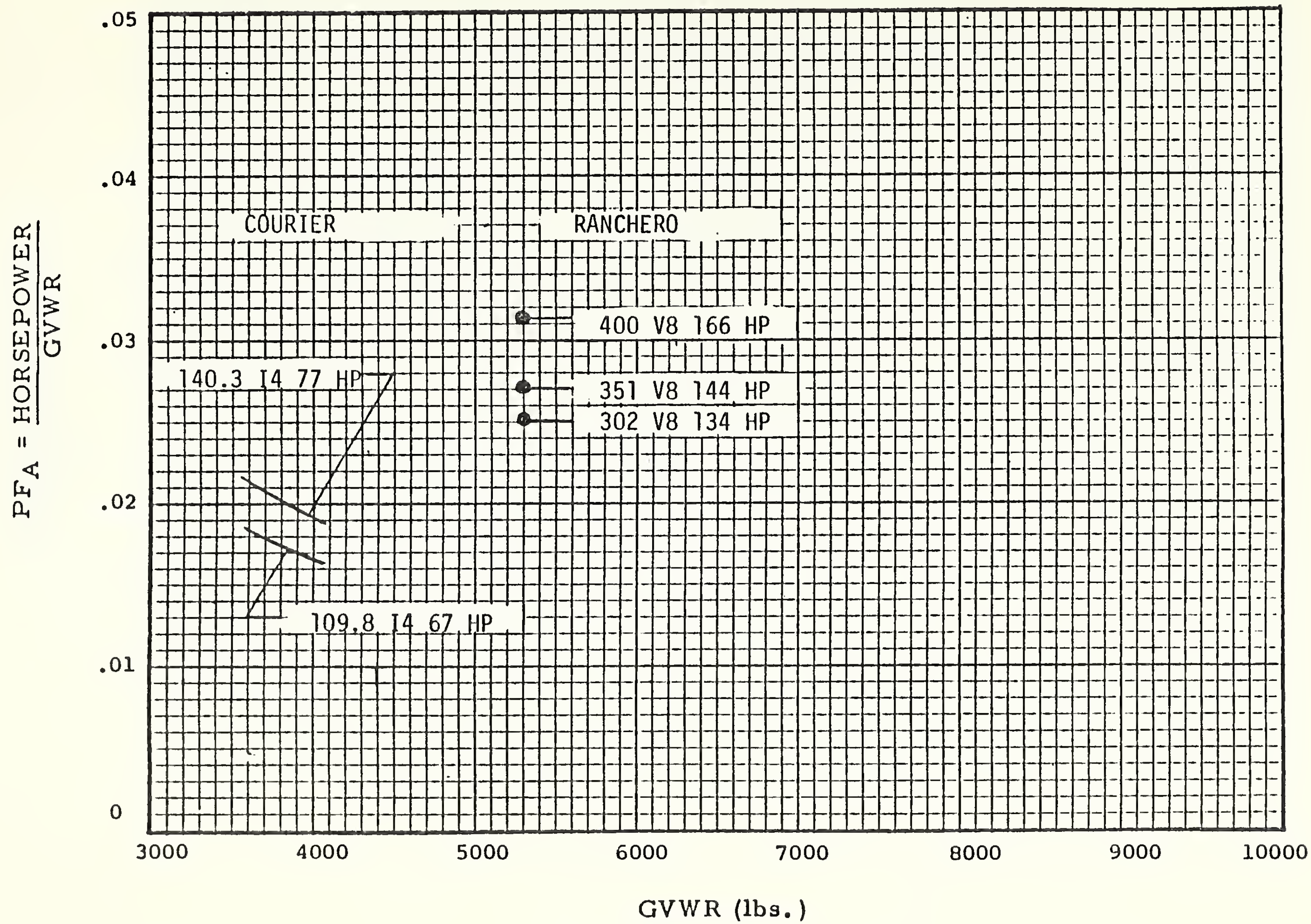
PERFORMANCE POTENTIAL

MAKE FORD TYPE PICKUP



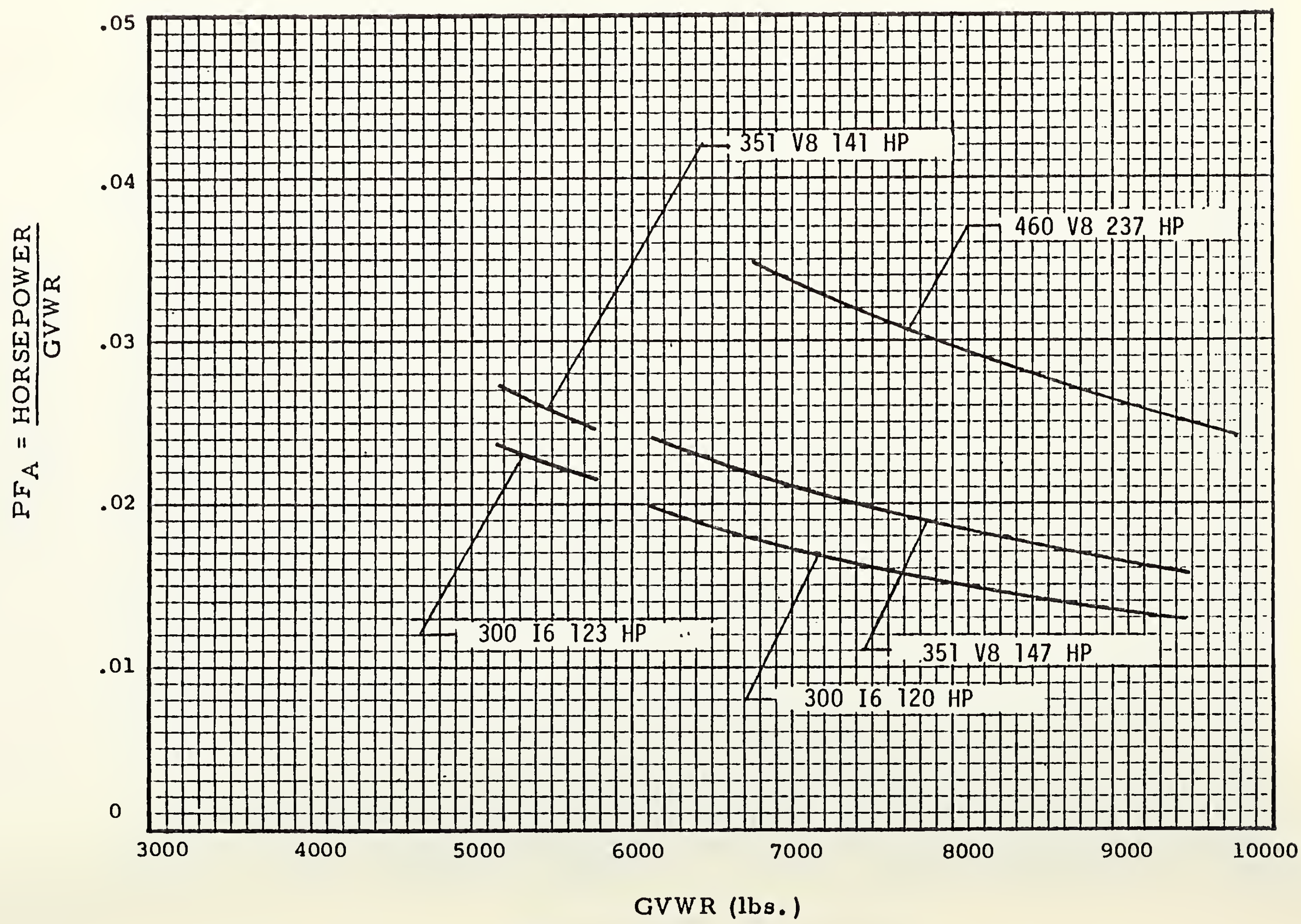
PERFORMANCE POTENTIAL

MAKE FORD TYPE PICKUP



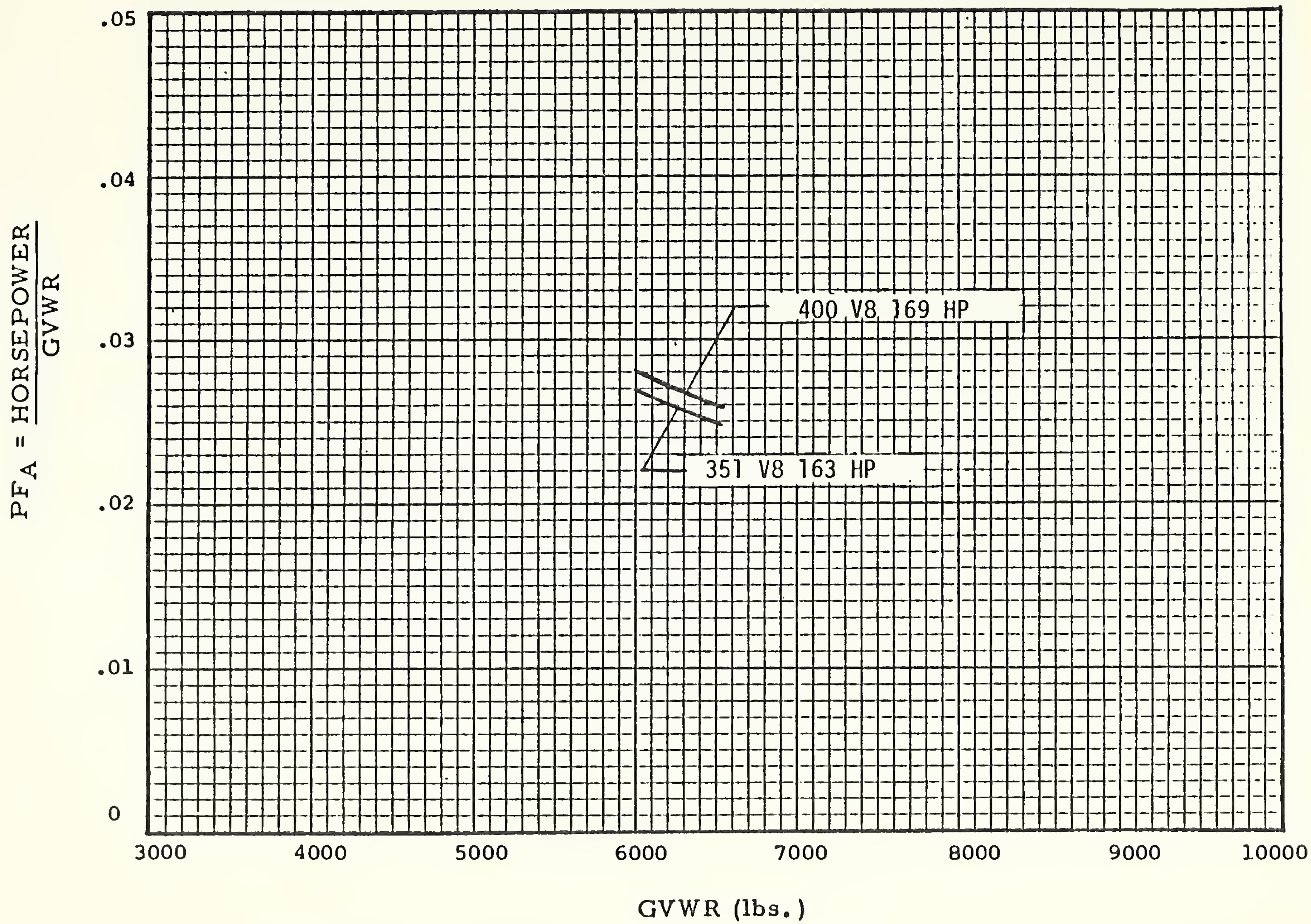
PERFORMANCE POTENTIAL

MAKE FORD TYPE VAN



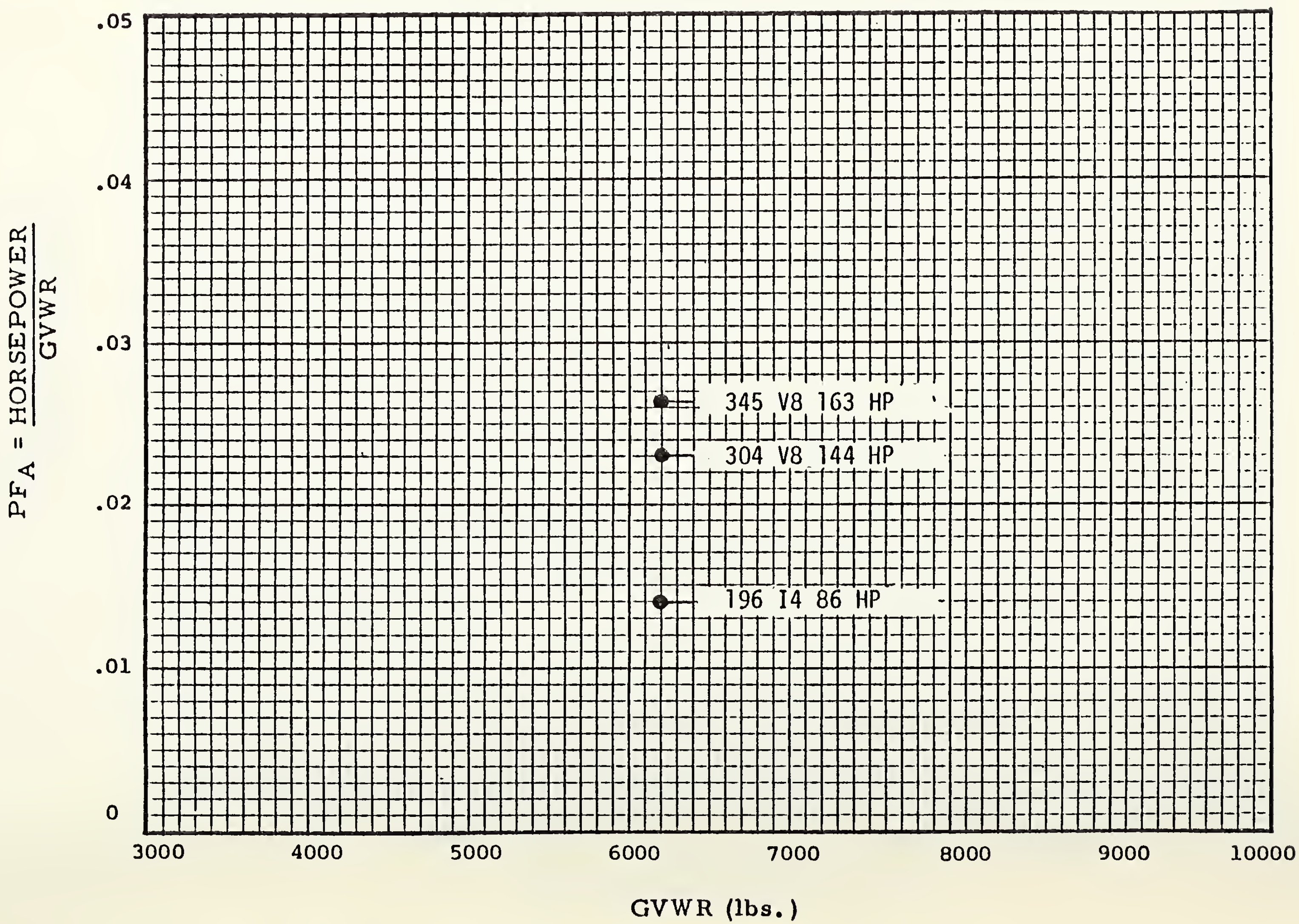
PERFORMANCE POTENTIAL

MAKE FORD TYPE UTILITY



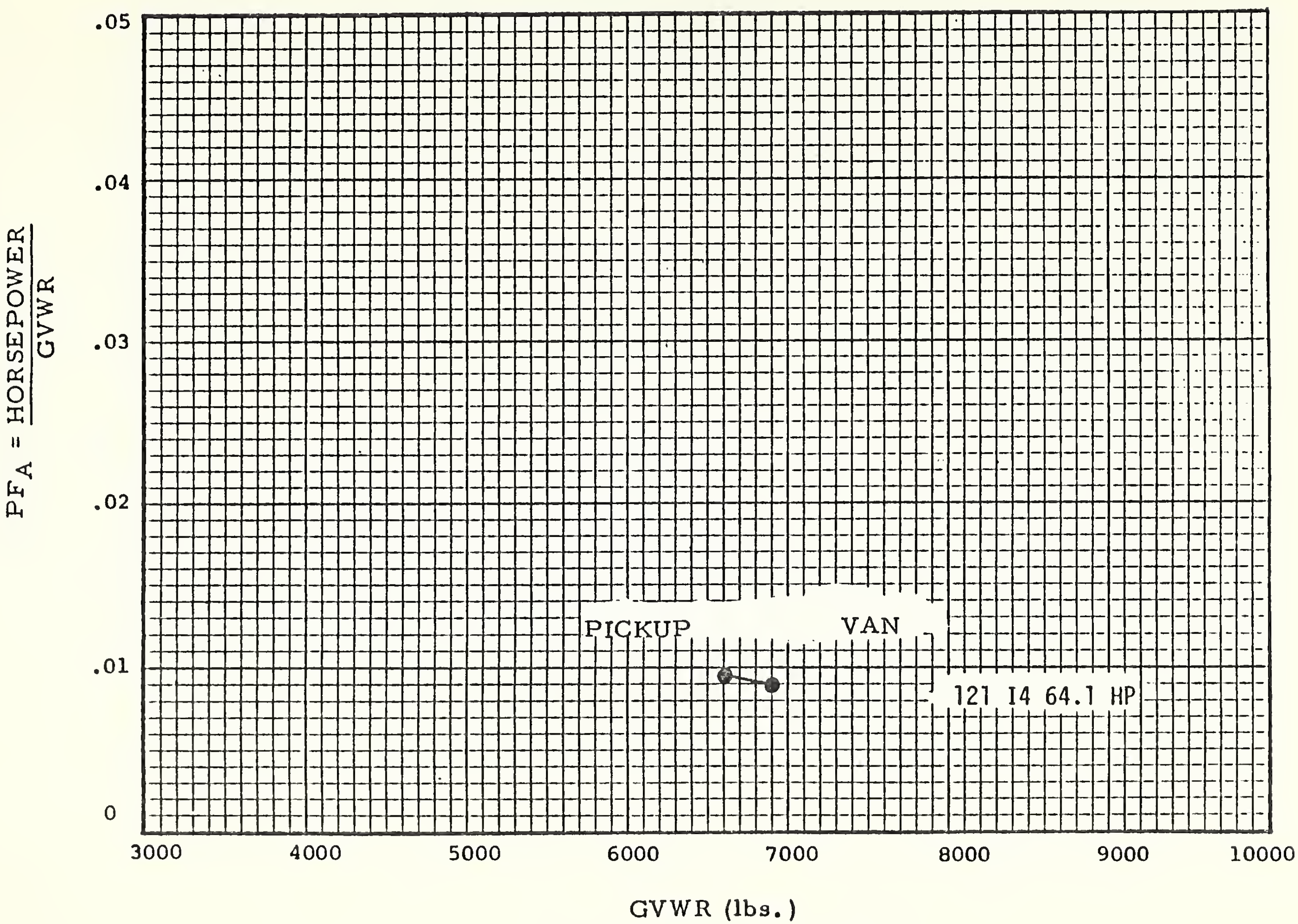
PERFORMANCE POTENTIAL

MAKE INTERNATIONAL TYPE UTILITY



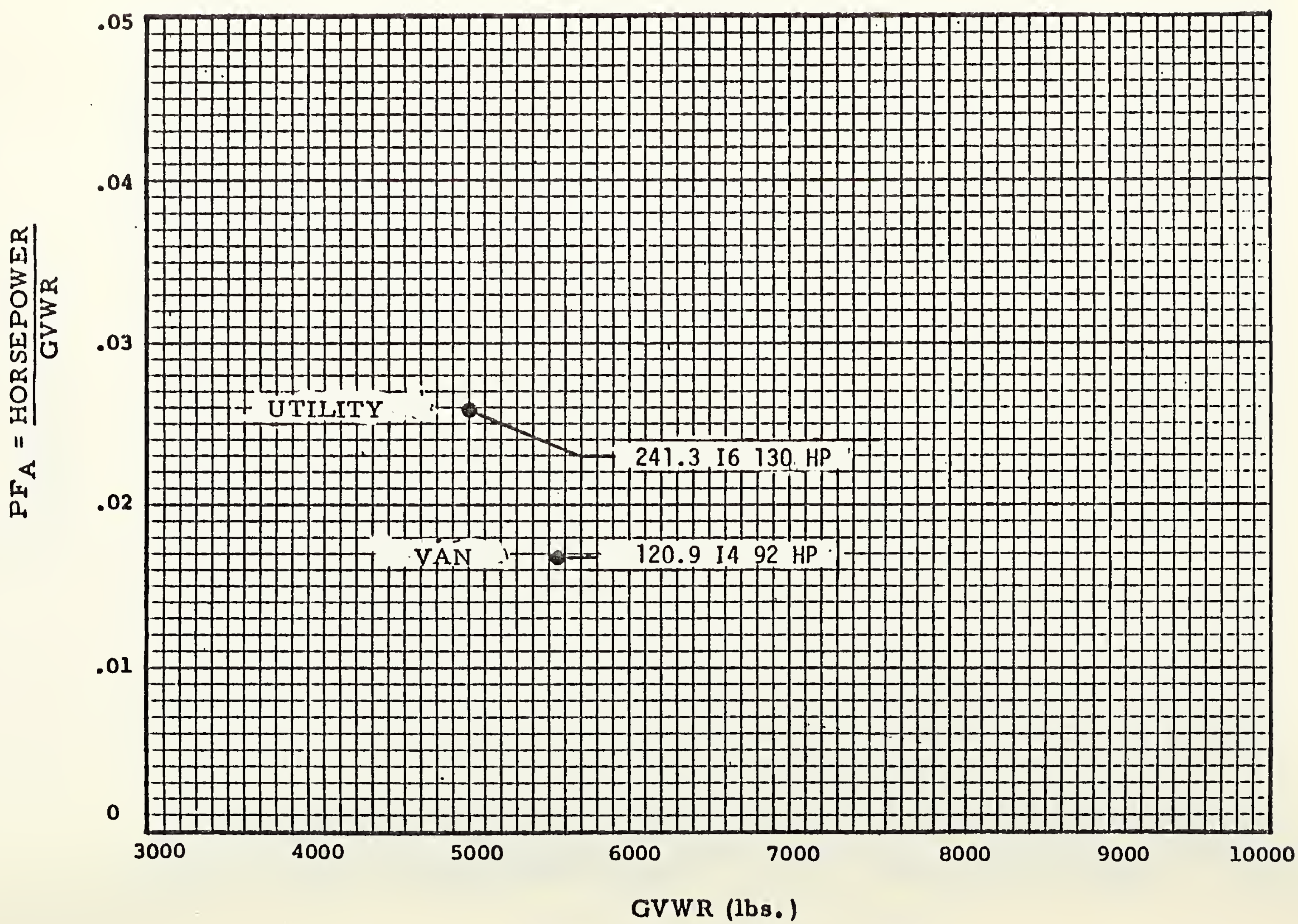
PERFORMANCE POTENTIAL

MAKE CITROEN - FIAT TYPE VAN & PICKUP



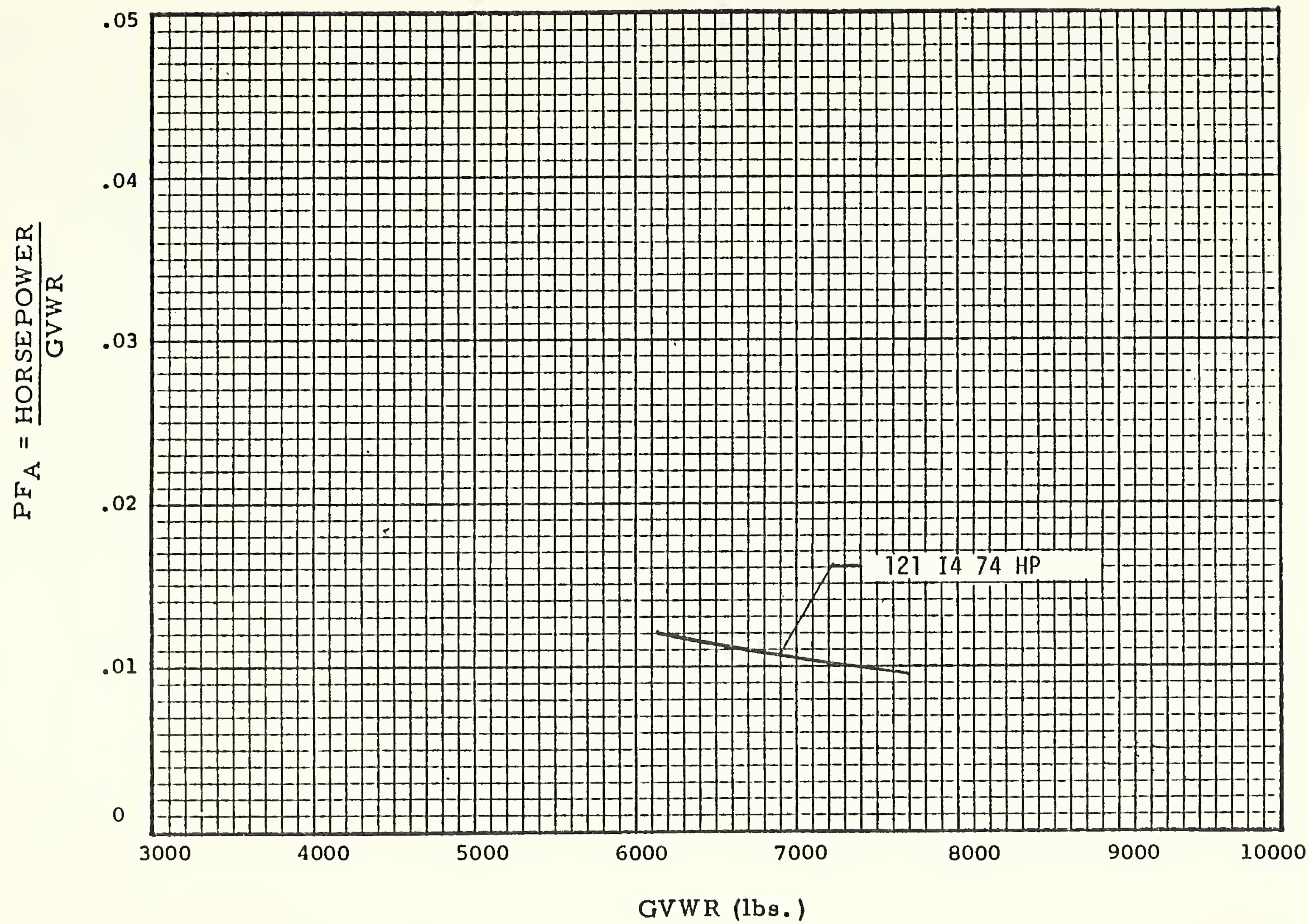
PERFORMANCE POTENTIAL

MAKE NISSAN - DATSUN TYPE VAN & UTILITY



PERFORMANCE POTENTIAL

MAKE VOLKSWAGEN TYPE VAN



APPENDIX E

DESIGN FORMULA DEVELOPMENT

Automobile structural components are generally characterized by stiffness or strength critical criteria or often a combination of both. Stiffness critical components are classified as either Flat Plates or Other Sections (Box, Channel or Convoluted). If stiffness is to be maintained then the product of Material Modulus and Section Moment of Inertia must be equal for initial and substitute designs.

Although the determination of the Moment of Inertia of a section is a rather complex calculation, it can be reduced to a simple formula for purposes of comparing similar designs. For Flat Plates this simplification indicates that the Section Inertia is proportional to the cube of material thickness and for other configurations it is linearly proportional to material thickness. Therefore, stiffness critical components do not offer a potential for weight reduction unless they can be classified as a "Flat Plate." Fortunately, many automotive panels function approximately as Flat Plates even though they do not conform to the theorectical definition. The Flat Plate relationship is:

$$Et^3 = E^1(t^1)^3$$

where:

E = Material Modulus - current

E^1 = Material Modulus - proposed

t = Material Thickness - current

t^1 = Material Thickness - proposed

and:

$$\frac{(t^1)^3}{t^3} = \frac{E}{E^1}$$

the weight relationship is:

$$W^1 = W\frac{w^1}{w}\sqrt[3]{\frac{E}{E^1}}$$

Where:

W = Component Weight - current

W^1 = Component Weight - proposed

w = Material Sepcific Weight - current

w^1 = Material Specific Weight - proposed

On the other hand, the corresponding relationship for Other Sections would be:

$$W^1 = W\frac{E}{E^1}\frac{w^1}{w}$$

which indicates:

1. Use of higher strength versions of the same material (HSLA vs. low carbon steel for example) would not reduce weight since the Material Modulus is unchanged.

2. Substitution of a common lightweight material (aluminum) would not save weight because the Material Modulus and Specific Weights are inversely proportional. Commonly used plastics such as SMC (sheet molding compound) would actually result in weight increase.

For reference, the properties of the materials used in this study are:

MATERIAL PROPERTIES

	E MODULUS 10^6 PSI	W DENSITY lbs./in.^{3}	S TENSILE STRENGTH 1000 PSI
Steel	29	0.283	28 LCS
			50 HSLA
Aluminum	10	0.100	50
HMC (Plastic)	2.0	0.064	30

As a result of the foregoing explanation, the only structural components which will be considered in the weight reduction analysis of this study, are those considered to be in the Flat Plate category.

Based on experimental results, it also appears that a reduction in stiffness can be utilized to achieve a reduction in weight. It is therefore assumed that 75% of current level for major parts and 60% for "hang-on" parts will produce acceptable performance. The following formulas will be used to determine the weight reduction potential for reduced stiffness levels and material substitutions.

For a common material at 75% and 60% current stiffness, the proposed weights would be:

$$W^1 = W \sqrt[3]{\frac{E}{E^1} \frac{(w^1)}{w}}$$

$$= W \sqrt[3]{0.75} = 0.19W \text{ - for major structure members}$$

$$= W \sqrt[3]{0.60} = 84W \text{ - for "hang-on" parts}$$

where W and W^1 are as previously defined with units of lbs.

For the material substitutions to be utilized, the formulas are:

Aluminum vs. Steel
at 75% Current Stiffness

$$W^1 = W\frac{0.100}{0.283}\sqrt[3]{0.75 \times \frac{29}{10}} = 0.46W$$

at 60% Current Stiffness

$$W^1 = W\frac{0.100}{0.283}\sqrt[3]{0.60 \times \frac{29}{10}} = 0.425W$$

HMC (Plastic) vs. Steel
at 75% Current Stiffness

$$W^1 = W\frac{0.064}{0.283}\sqrt[3]{0.75 \times \frac{29}{2}} = 0.50W$$

APPENDIX F

REPORT OF NEW TECHNOLOGY

No inventions have been achieved during the performance of work under this contract. The work consisted of:

a. Definition and documentation of the Light Duty Truck fleet up to and including 8500 lbs. GVWR. The documentation is exhibited in APPENDIXES B, C, and D. Significant comparisons of selected attributes are presented in Section 2.5.

b. Establishment of the Weight Saving Potential for these vehicles by means of Design Modification, Redesign and Material Substitution. Results of the weight reduction are shown in Table 5-12.

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